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DISCOVERY

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The Progress of Science

Lost Papers

THE death of Dr. F. W. Lancaster a few weeks ago recalls our attention to that perennial problem of science—the piece of revolutionary scientific work whose importance goes unrecognised, often till its rediscovery many years later. There is no need to enlarge here on Lancaster's contributions to science and technology, for instance in the development of internal combustion engines and the motor car, in acoustics and, above all, in aerodynamics. But it is well to dwell a little on the latter as one of the outstanding examples in modern times of unrecognised scientific work.

About 1894 Lancaster began his investigation of aerofoil theory and soon developed the circulation theory which is now familiar as the basis of the subject. In 1895 he read a paper on it to the Birmingham Natural History and Philosophical Society. It was not printed. In 1897 he submitted a paper dealing with it to the Physical Society of London. It was rejected. The work did not appear in print till the publication of his book, *Aerial Flight*, in 1907. In the preface to that work Lancaster comments thus on the Physical Society's action: "The rejection of this paper was probably due to an unfortunate selection of the readers to whom it was submitted. The names of the Society's readers are not disclosed, but from the wording of the reports (which the author is not at liberty to quote), it would seem that the recognised application of the Newtonian method (as in the theory of repulsion) was a thing unknown to them."

Even after the publication of the book, Lancaster's work remained largely unappreciated in this country, but its worth was recognised by Prandtl of Göttingen, who was then working along similar lines. In spite of the fact that Prandtl fully recognised his debt, the circulation theory came to be known as Prandtl's theory, and it was not till some years later that Lancaster's name was coupled with his.

This story prompts one to recall some earlier examples of neglected work. There was Mendel's great paper, "Experiments in Plant Hybridisation", which laid down the foundations of genetics. It was published in 1866, but unfortunately in an obscure local periodical, the *Journal of Brünn's Natural History Society*. Thus it remained unknown till 1900, when de Vries, Correns and Tschermak independently reached the same conclusions as Mendel, and in ignorance of Mendel's work. It was de Vries who found Mendel's 'lost paper' in the course of a systematic search of the literature, prompted by the results of his research on discontinuous variation. When one recalls that Darwin worked in entire ignorance of Mendel's achievements, one can see easily that profound effects on the history of biology arose from that lost paper. It is not impossible that if the subject of genetics had got under way 34 years earlier than it did it might by now have yielded very much greater practical fruit.

Then there was Avogadro's famous 'hypothesis', first published in 1811, but not recognised by the scientific world till Cannizzaro forced it into prominence in 1859. During those intervening years the whole of chemistry remained in a state of confusion attributable almost entirely to the failure to recognise this one very simple basic principle. In this case the world of science does not have the excuse that the work was published in some obscure way. It appeared in the very important French periodical, *Journal de Physique*. Various excuses have been urged. Tilden, for instance, suggests that "The word *molecule* was then unknown in scientific literature, and being freely used by Avogadro in his first memoir it probably led to some confusion in the minds of the readers, and induced them to attribute to him a confusion that did not exist." Actually the word was very common in the scientific literature of the early nineteenth century, though naturally not used with modern precision. And apart from that, the scientific mind ought not to be frightened of strange words. No, the reasons for the universal neglect of Avogadro's work must be sought deeper than this; they will doubtless be found to be complex, and it is likely that the full explanation would involve factors outside the bounds of science in the strict sense. There is still a lot of scope here for historical research.

Another example of a worthy paper ignored is that which Waterston read to the Royal Society in 1846.

It anticipated by about 15 years much of Maxwell's work on the dynamical theory of gases. Yet it was merely relegated to the archives of the Society. Waterston put his work before the British Association in 1851, but it still remained unnoticed. And he published it in the *Philosophical Magazine* in 1858, with no better effect. It remained virtually unknown till Rayleigh discovered the original paper in the archives in 1892.

In this case there are more obvious reasons for the neglect, though the ones we note here may be far from complete. The established institutions of British science showed a marked tendency till about 1860 to neglect or ignore physical work of a certain type. The type has been briefly described as the fundamental physics that lay behind the problem of the efficient use of the steam-engine. That is probably far too narrow and schematic a description, but it contains a germ of truth. A large part of the research leading towards what became the subject of thermo-dynamics was carried out by men who were to some extent influenced in their outlook by the enormous expansion of power-driven machinery in the north—not so much men working on technological problems as those who (like Joule) lived in that general social atmosphere and whose scientific interests were naturally influenced to some extent by their surroundings. In an industrial context the mind of a scientist seeking problems would naturally tend to be unconsciously directed to problems of energy exchanges and the properties of heat in relation to gases rather more often than would happen in other conditions. But the established institutions belonged to a different social context—and this applied particularly to the Royal Society of this time—with the result that they tended to underrate the importance of work of the thermo-dynamic type. Waterston's paper is one example; another is that two of Joule's important papers leading up to the establishment of the Principle of the Conservation of Energy were published by the Royal Society only as abstracts.

When considering the effects on the development of science arising from these lost papers, it is rather easy to dismiss the matter as 'merely of historical interest' on the grounds that 'it could not happen now'. But perhaps that statement deserves critical examination. It is no argument to say that one cannot quote examples from the last decade or so—for valuable papers might at this moment lie unrecognised in some of the less read journals. There may be social inhibitions that would act against the proper evalution of certain types of work, as the mid-nineteenth century conditions acted in the cases of Joule and Waterston—that is certainly not unlikely in some branches of, for example, the social sciences, and even perhaps in parts of biology. And we have no reason to suppose that scientists have completely abolished the mental prejudices which have sometimes prevented the recognition of the worth of a new idea.

Further, there is certainly far more room than ever before for papers to get lost. In spite of abstracting services, the total number of journals has grown so large that there are far too many places where valuable work could be published and yet only reach a small number of readers, who might easily fail to include one fit to assess its value. It only requires a certain degree of false modesty on the part of the author for the paper to get no farther than a journal of only local circulation. This is just one more reason, added to many others, why the scientific family ought to be far more strenuous in its efforts to put the publication and communication wing of its house in order.

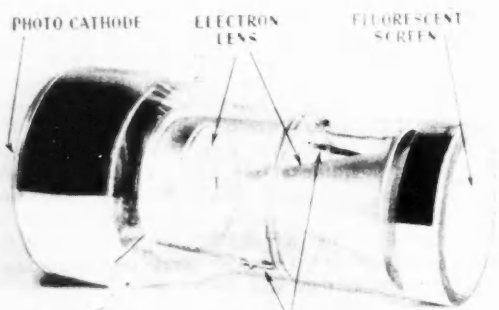


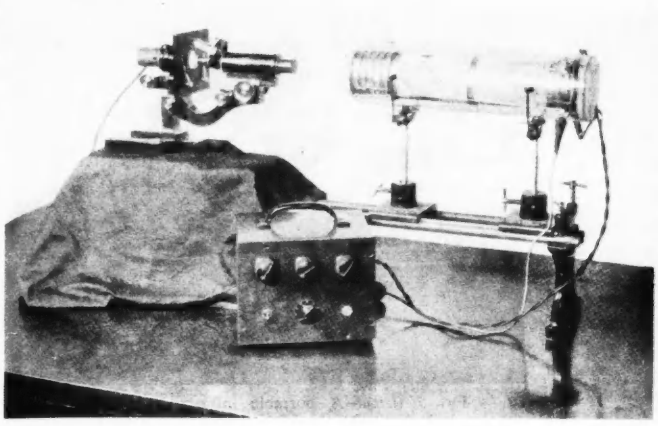
FIG. 1.—German image converter tube. An infra-red image formed on the photo cathode is reproduced in visible light on the fluorescent screen.

German Uses of Infra-red

IN contrast to their slow development of radar equipment, the Germans paid much attention to other means of determining the positions of unseen objects, and by the end of the war they were using a number of ingenious devices which depended on their sensitivity to infra-red radiation. Nearly all the phenomena on which these devices are based were known before the war but considerable advances have been made in the preparation of sensitive materials and in technique for their application.

Infra-red radiation is emitted by all hot bodies, whether or not they are hot enough to emit visible light as well. The Germans made infra-red searchlights by covering the front of an ordinary searchlight with a special glass filter which absorbed the visible rays but transmitted the infra-red. In many applications, however, no searchlight is necessary because the exhaust pipes of internal combustion engines in tanks and aircraft are themselves strong infra-red sources. Detectors of several types were developed. Some simply indicated the direction and strength of any infra-red source, while with others a complete picture of a scene illuminated by an infra-red searchlight was obtained.

The classical method of detecting infra-red radiation relies directly on the heating effect of the rays when they fall on a black object. Later, specially sensitised photographic plates were developed with which photographs could be taken through mist and haze owing to the very slight scattering of infra-red radiation by these hazards, but neither of these methods are suitable for service use. The most sensitive device used by the Germans is a resistance photocell—similar in its action to the earliest form of selenium cell. When light falls on solids of the type known as semi-conductors, the energy of the radiation, provided it is of a suitable wavelength, is not immediately converted into heat but is used to excite electrons in



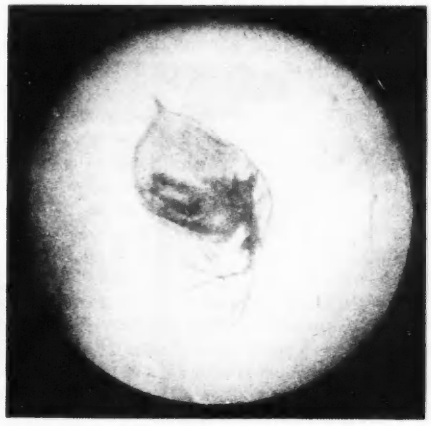


FIG. 2 (*left*).—An infra-red microscope which was devised ten years ago. The infra-red image formed by the optical microscope on the photosensitive surface of the image converter tube (on right) is translated into a visible image on the fluorescent screen at the right-hand end of the tube. FIG. 3 (*right*).—A micrograph—of a water-flea—obtained by means of this apparatus. Infra-red images of micro-organisms can reveal structural details that cannot be seen by visible light. (From *Journal of the Optical Society of America*, 1936, Vol. 26.)

the solid from their normal states to states of higher energy. The presence of these excited electrons causes a number of changes in the electrical properties of the material—notably its resistance is reduced or its dielectric constant altered. The wavelengths which are effective are related to the energy differences between the normal and excited states of electrons in the solid. In the resistance cell a material with a suitable wavelength sensitivity is incorporated in an electric circuit and a potential of about 10 volts applied to it so that a small current flows. When radiation falls on the cell the resistance decreases and the current rises in proportion to the intensity of the radiation. The success of the German cells rested on the development of a method of preparing lead sulphide cells which were highly sensitive to all wavelengths in the infra-red range from 0·8 to 5 microns. The sulphide was deposited either chemically or by evaporation on a glass plate and then 'ripened' by heating in air. The currents are amplified by normal methods and the entire assembly is claimed to have a sensitivity of the order of 10^{-10} watt. This means that a 1 cm. square cell would be able to detect an ordinary (1Kw) electric fire at a distance of about 10 miles, assuming there was no atmospheric absorption. To avoid spurious effects due to heating of the cell by the current passing through it the cells were normally cooled to – 70° C. with solid carbon dioxide.

Materials whose dielectric constants change under illumination include a number of well-known luminescent materials of the zinc-sulphide/cadmium sulphide class. Special methods of preparation, such as firing at high temperatures and pressures, enhance this property considerably. Condensors were made consisting of a metal plate, a layer of sensitive material and a fine gold mesh to form the second electrode. Infra-red radiation falling through the gold mesh on to the material causes a change in the capacity of the condensor. By making the condensor part of an oscillating circuit these changes are revealed as changes in the frequency of the oscillation.

The DK cell (depending on the dielectric constant changes) and the resistance cell, known as the ELAC cell, were used for detecting aircraft, tanks or shipping by their own radiation. One type of glider bomb contained a 'homing device' by which it steered itself towards an aircraft's exhaust pipe, no matter what evasive action the pilot might take. Such cells were also used for signalling in conjunction with a small infra-red lamp. One signalling device of this type which converted speech into an intensity modulated light or infra-red beam and back again was described in DISCOVERY for January 1944 (p. 31).

Although falling far short of radar in range and accuracy these methods of detection have the advantage of being undetectable by the enemy—the aircrew cannot tell when the radiation from their plane's exhaust pipe is exciting an infra-red cell but they do know when they are reflecting a radar beam. Similarly, signalling with a narrow infra-red beam is far more private than radio communication.

Finally there is the infra-red telescope. (Figs. 5–7.) This is a development of the image converter tube, a device which has long been used for increasing the strength of weak light images and had in fact been used with infra-red radiation in Holland in 1934. (Figs. 1, 2, 4.) One end of an evacuated glass tube is coated with a thin metal layer known as a photocathode which emits electrons into

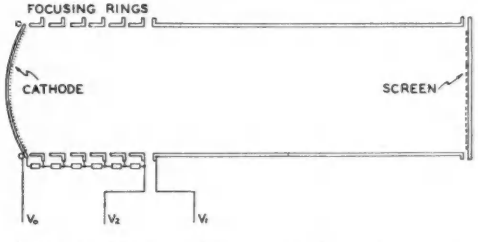


FIG. 4.—Diagram of electrostatic image converter tube of the type shown in Fig. 2.

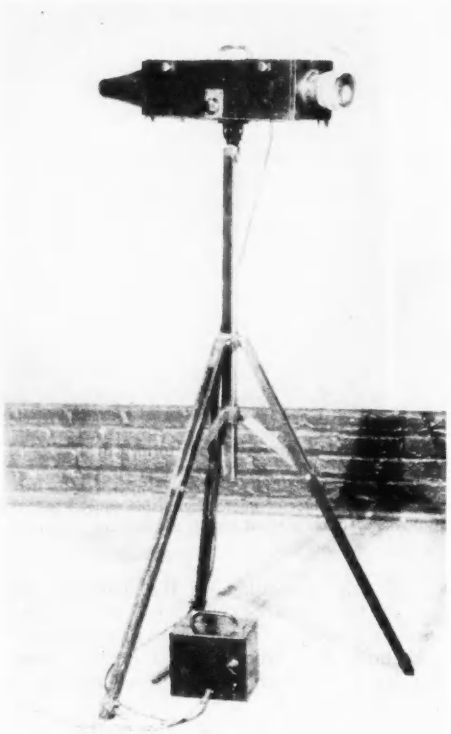


FIG. 5 (*left*).—A portable infra-red telescope, of which details were published in 1936. (From *Journal of the Optical Society of America*, Vol. 26.) FIG. 6 (*above*).—The Germans utilised a similar infra-red device in such weapons as the sniper's rifle pictured here; the target when illuminated by the beam from the infra-red searchlight is seen in the telescopic sight. The U.S Army also used this weapon.

the vacuum when illuminated. At the other end is a fluorescent screen which emits light when bombarded by electrons. Between these two components is arranged a system of electron lenses, similar to those used in a television camera or an electron microscope, which accelerate the electrons emitted from the cathode and focus them on to the fluorescent screen. An infra-red image formed by normal optical means on the photocathode is reproduced in visible light on the screen. The photocathode consists of a layer of specially treated silver oxide on caesium, and a potential of 20 Kv is used on the electron lens. If the resulting image is too weak a second converter tube is placed in series with the first having a photocathode sensitive to the light emitted by the screen of the first tube. These telescopes were used for reconnaisance under cover of darkness, an infra-red searchlight providing the necessary 'illumination'.

In developing these devices Germany undoubtedly benefited very considerably from the enormous amount of experimental work on semi-conductors of all kinds which had been carried out there before the war. The subject is one in which British scientists were well advanced on the theoretical side but very backward in experimental investigations. Semi-conductors have many important properties which depend very strongly on the past history of the individual sample, and extraordinary care must be used in their preparation if any given set of properties is to be reproduced. Theories about these materials are complicated and controversial, but it is generally agreed that once they are fully understood many wider problems connected with the solid state will be readily explained.

It is interesting to note that infra-red *microscopy* is also possible using the image converter tube. Figs. 2 and 3 show the kind of arrangement that is used, and the sort of result that can be achieved.

Accentuate the Feminine

THE introduction of an alien species into a country where it was previously unknown has sometimes given rise to very serious problems; the rabbit has taught Australia this, and the plant kingdom provides many similar examples—the water hyacinth and Canadian pondweed are now notorious pests. The aphid Phylloxera, accidentally introduced into France about 1865 with some vine roots

FIG. 7.—This image was obtained with the infra-red telescope shown in Fig. 5.

from America, almost ruined the wine and grape industry before being brought under control, while three years later, as if to even the score, a few Gipsy moths made the same journey, but in the opposite direction, from France to Massachusetts. These escaped accidentally and, establishing themselves, caused serious caterpillar plagues within twenty years; fruit and shade trees were completely defoliated, and if this was repeated for two or three seasons the trees died. The area of infestation continued to spread and the Gipsy moth is still one of the most serious pests of New England, in spite of energetic control measures costing about £15 million during the past 30-40 years. In addition to measures such as painting the trees with creosote to kill the eggs, the banding of trees and the use of lead arsenate sprays to poison the caterpillars, biological control methods have been tried. Natural parasites of the Gipsy moth, such as the European *Calosoma* beetle and certain Tachinid flies have been introduced and allowed to establish themselves.

Until successful control is achieved, the search for new and better methods of control continues. One rather novel idea is being investigated by the United States Bureau of Entomology, based on the remarkable olfactory powers of the moths. The female does not fly, but attracts the males by secreting a scent which is odourless to man and is quite specific, attracting only male Gipsy moths. It has long been known that males could be captured by baiting traps with live virgin females, and later experiments showed that this was due to a scent in the female abdominal tip, and that the tips could be removed and treated with organic solvents to give an extract highly attractive to male moths. This extract has been used in 'scouting traps' to study the distribution of the moth, but it is clear that the use of this natural product is impracticable as an actual control measure. There would be interesting possibilities, however, if the scent could be synthesised cheaply in bulk, as the widespread use of mass-produced scented traps might make it possible to attract the male moths away from the orchard, leaving the females unfound and unfertilised. The males misled by the traps could be killed easily by the use of a modern insecticide such as DDT or gammexane.

Various laboratory chemicals have been tested in the hope that an effective substitute might be found for the scent, but without success, and so attention is being directed towards the natural material, in order to try to discover its chemical structure which is still largely unknown. As in the investigation of a new vitamin or hormone, it is first necessary to obtain an adequate amount of the cured material and then to follow the course of separations and concentrations by biological tests. The American workers* bred Gipsy moths in the laboratory and then cut off the abdominal tips from 46,000 unfertilised females and prepared an extract. Activity was assayed by counting the number of male moths caught in a trap baited with a sample of the material. As an example of experimental procedure, the scent was shown to be chemically neutral by separating a crude extract into acidic, neutral and basic fractions, and using these to bait traps, when the catches were respectively 4, 109 and 3 moths.

Frequently a natural product is found to have relatively simple structure, and can be built up in the laboratory and factory—indigo is an example—but sometimes the structure turns out to be too complex for the synthetic chemist to reproduce with his present knowledge and techniques—such is the case with insulin and penicillin. There is still a great deal of work to be done on the natural scent before a blueprint of the molecule can be drawn, and only then shall we know whether its chemical synthesis will be possible. Further developments in the chemistry of this scent will be awaited with interest.

The olfactory sensibility in moths is quite different from that man's. Although the amount of scent secreted by a moth must be very small, Mell found that when marked male Chinese moths were released from a train, 26% were successful in finding an imprisoned female in a gauze cage seven miles away. J. H. Fabre made many interesting experiments with the Oak Eggar and with the Emperor moth, and the remarkable results are described in his *Social Life in the Insect World.*

* Haller, Acree and Potts. *Journal of the American Chemical Society*, Vol. 66, 1659, (1944).

John Owens and Manchester University

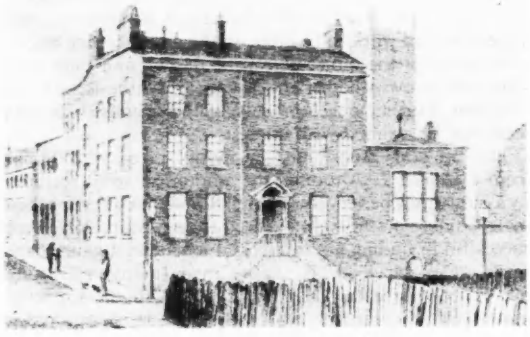
"On the 29th ult., aged 55 years, John Owens, Esquire, of Nelson Street." That obituary notice in the *Manchester Guardian* of August 1, 1846, would not have attracted much attention in the scientific world of that day. Yet the will of this John Owens was to have very far-reaching effects on science; to give a topical example of the influence it has had, that will can be related to the election of the president of the Royal Society in 1946; the relationship will emerge in due course.

John Owens was a Manchester business man of some eminence. He belonged to the commercial rather than the manufacturing side of the textile industry, and so had little direct interest in even the applied side of science. Though no great public figure, he was an advanced liberal for his day, a supporter of Free Trade and of the Anti-Corn Laws Association. But he held very strong views about education, especially about the religious tests that closed the doors of Oxford and Cambridge to non-conformists—and therefore to the sons of a great part of the manufacturing and commercial classes.

To these opinions he gave effective expression in his will, in which he left £96,654 11*s.* 6*d.* "for the foundation of an institution within the Parliamentary borough of Manchester . . . for providing or aiding the means of instructing and improving young persons of the male sex . . . in such branches of learning and science as are now or may be hereafter usually taught in the English Universities, but subject, nevertheless, to the fundamental and immutable rule and condition that *the students, professors, teachers, and other persons connected with the said institution shall not be required to make any declaration as to, or submit to any test whatsoever of, their religious opinions;* . . ."

At a time of political troubles at home and abroad, the realisation of Owens's estate was a slow and difficult matter, but by 1851 it had been completed and Owens College began its life. This College later became the nucleus of the Victoria University of Manchester, which was established in 1880.

The absence of religious test was the special characteristic of the new college, which caused it to become an



Owens College as it was in 1851.

important member of the group of two or three leading institutions which led the struggle to spread modern science in England. At that time the older universities, though these had partially recovered from the extreme decadence to which they had fallen fifty years or so earlier, still approached 'natural philosophy' from a viewpoint more appropriate to the seventeenth century than to the nineteenth. Science to them was still largely mathematics, together with lectures on natural philosophy and chemistry, supported by occasional, carefully chosen demonstrations. Real experimental teaching was rare. The choice of topics bore little relation to the growing points of science. Research, when it occurred, was the by-product of the leisure of a don's life, rather than a normal activity of the universities.

Nor was this unconnected with the religious tests. They restricted the universities effectively to the aristocratic and landowning classes, who had no special reason to be generally interested in science (though a few representatives of these classes did great scientific work—*as individuals*). The people who were most likely to insist on a change in the attitude of the universities as corporate bodies belonged to the manufacturing classes, who tended on the whole to be non-conformists. And these were excluded from the universities. The go-ahead scientist could only with difficulty find a place for himself in these institutions. Unless he had an independent income, he was driven to work in those centres of learning which, being free from religious test, were open to the attention and encouragement of manufacturing interests. In these was provided an atmosphere more congenial for science; this was due partly to the direct interest taken in its technological applications, but more because it was believed in these institutions that science was an important element in the advance of civilisation and that it was, while not tied to its uses, often extremely useful. (It is significant that another college with non-conformist origins—London's University College—should develop very strongly on the scientific side).

Such institutions were few, and the creation of another in Manchester was therefore an extremely important event in the growth of modern science. During the time Oxford and Cambridge were showing little favourable reaction to science (their attitude did not change until near the end of the century), Owens College was playing a full part in the advancement of research and the spread of scientific learning. It did more than its share in the development of chemistry; and it is only a trivial exaggeration to say that it and it alone is responsible for the creation of modern organic chemistry in this country.

First Professor of Chemistry was Edward Frankland, who laid in 1852 the foundations of the theory of chemical valency. He was succeeded by Henry Enfield Roscoe. A good administrator, as well as an excellent teacher whose emphasis was always on the laboratory rather than the lecture room, he turned the College into the chief British centre of chemistry. Of his own researches the most outstanding were those on vanadium and its compounds, but he also covered a wide field, including the fundamentals of photo-chemistry, the physical properties of solutions of volatile acids, and many other things. And he was largely responsible for promoting a proper appreciation in Britain of the value of spectroscopic analysis. On the organic side great steps were made by Carl Schorlemmer, who held various positions in the College from 1861 on and in 1874 was appointed Professor of Organic Chemistry—the first appointment to the first chair of the subject in this country (note that the date coincides with that of the establishment of the first laboratory of any sort at Cambridge—the Cavendish—and anticipates the Cambridge chemical laboratory by three years). Schorlemmer is best known for the work which elucidated the nature of the normal paraffins, showing the falsity of the current view that there were two isomeric series, regarded as alcohol radicles and hydrides of alcohol radicles, respectively.

Among the many other teachers of Owens College or Manchester University who made their mark on chemistry, we can mention only a few: F. Guthrie, T. E. Thorpe, W. C. Williams, M. M. Patterson Muir, P. P. Bedson, H. B. Dixon, G. H. Bailey, P. J. Hartog, W. N. Haworth, W. A. Bone, D. L. Chapman, W. H. Perkin, J. F. Thorpe and Chaim Weizmann. That list brings us into the present century, and still Manchester, with a few other provincial centres, was far more important than Oxford and Cambridge in organic chemistry. When at last these older universities became alive to the needs, Manchester played a central part in providing the men they needed to create their organic schools. The reputation of the Oxford school, for instance, has been largely built around two successive Waynflete Professors, W. H. Perkin and Sir Robert Robinson—both products of Manchester. And the mention of Sir Robert Robinson's name explains our opening remark connecting John Owens's death with the latest President of the Royal Society.

In other scientific fields the position of Owens College and Manchester University was not quite so outstanding. Yet it can boast many famous names among its staff and students: W. S. Jevons (of *Principles of Science* fame), Horace Lamb, Arthur Schuster, Balfour Stewart, Osborne Reynolds, J. J. Thomson—these eminents of the last century come immediately to mind, and many more names could be added to this short list.

This is no mean record for the product of a request of a mere £96,000. Perhaps one of the reasons (besides the absence of religious test) that so small a sowing could yield so vast a harvest lay in a simple financial decision

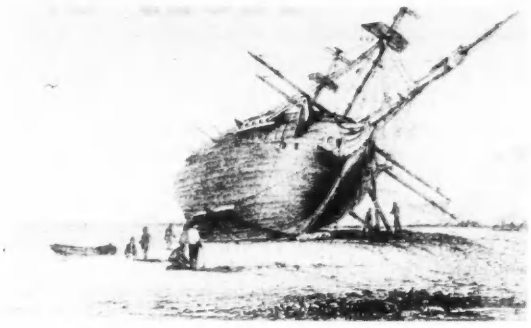
made at the beginning by the founders of Owens College. They realised that if much of this money were spent on buildings, they would be unable to provide an adequate staff. They therefore decided to devote the funds primarily to salaries and were content to start the College in a very ordinary house at a rent of £200 a year. That explains why so meagre an endowment could support so brilliant a staff.

'The Beagle' and the Earthworm

THOUGH time has brought a considerable modification to the theories of evolution that Darwin left with us, he is still held in the highest esteem for having made the greatest single contribution to the advance of knowledge and thought upon this subject. The importance of that contribution is appreciated very widely outside scientific circles, and there are few to echo the words of Matthew Arnold: "I cannot understand why you scientific people make such a fuss about Darwin. Why, it's all in Lucretius."

A measure of Darwin's pre-eminence is provided by the appearance at this time of acute paper shortage of a new edition of Darwin's book on earthworms (under the doctored title of *Darwin on Humus and the Earthworm;* Faber, 8*s.* 6*d.*) and of a new book containing many hitherto unpublished letters. The second book, *Charles Darwin and the Voyage of 'The Beagle'* (Pilot Press, 15*s.*), is a distinct addition to Darwiniana. Reproduced in their entirety are 36 letters which Darwin wrote to his family during that famous voyage which he described as "by far the most important event in my life", determining his whole career. The volume is edited by Lady Barlow (who edited the diary of the voyage, published in 1933 by Cambridge University Press), a grand-daughter of Charles Darwin. She has taken the bold step of also including excerpts from the 24 small note-books in which Darwin recorded his immediate impressions. This is daring indeed for Darwin's great champion—his self-proclaimed 'bulldog', T. H. Huxley—was scathingly critical of the quality of much of the descriptive writing in the note-books on the grounds that Darwin was at that time lacking in biological training. Lady Barlow's justification lies in the argument that the spontaneity of the note-books' contents, "because he wrote for himself and no one else, because they are rough hewn and incomplete", can "throw some human light on the mind that was undergoing such an experience and such a discipline". The notes on geology are not open to criticism in the same way that the biological notes are. When he left Plymouth on *The Beagle* in 1831 Darwin was better equipped to do justice to the geological phenomena he was to encounter, and his early note-books are characterised by a high proportion of geological entries. Here Lady Barlow has had the benefit of Dr. Kenneth Oakley's advice in interpreting some of the notes.

Darwin never ventured a theory without a convincing array of facts to back it. The compilation of those facts and their final synthesis took many years, and the care he took in documentation nearly cost him the credit for the theory which he and Wallace arrived at independently. His survey of the Galapagos Archipelago led to the observation that the tortoises on one island were remarkably similar yet sufficiently different—the inhabitants were able to "pronounce from which island any tortoise may



The Beagle laid ashore for repairs during the famous voyage. (From *Charles Darwin and the Voyage of 'The Beagle'*.)

have been brought". The doubt about the stability of species was thus laid in Darwin's mind in the autumn of 1835, and as Lady Barlow remarks, it is astonishing when we consider that more than twenty years were to elapse before this 'undermining' of the stability of species was sufficiently documented to be given to the world in the *Origin of Species*. Yet when one finds that it was in 1838 that Darwin first devoted attention to the part played by earthworms in soil formation, whereas his book *The Formation of Vegetable Mould through the Action of Worms* was not published till 1881, one realises that the point about the Galapagos observations is typical and not at all exceptional.

The reclamation of Darwin's book on earthworms from relative obscurity has been sponsored by the modern humus-anti-chemical-fertilisers school, and the Faber book carries a characteristic, hard-hitting foreword by Sir Albert Howard emphasising a connexion between Darwin on worms and Howard *et al.* on humus. Darwin's words are well worth reading; it is a very fine piece of scientific literature, compared with which many of our modern technical books seem cumbersome and inelegant. He was not content with restricting himself to records of observations about the habits of earthworms; he did not merely say 'This is how worms live for those people who are interested in this sort of natural history' but he also said 'This is how worms live in the soil and it is very important to the soil and to us.' He summed it up in the words: *The plough is one of the most ancient and most valuable of man's inventions; but long before he existed the land was in fact regularly ploughed and still continues to be ploughed by earthworms. It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organised creatures.* Yet the book does not seem to have had the deep impression that many of his other books did, though it prompted an American medical man, Dr. Oliver, to start an experimental worm farm which became a flourishing commercial enterprise through the sale of egg-capsules to farmers whose soil lacked worms. (Edgar Wallace, by the way, made money from Darwin's ideas in another way: he based a 'thriller' on the poisoning of earthworms as an effective form of sabotage!)

Darwin's figures suggested that about ten tons of earth-plus-organic matter pass through a worm each year.

Cont. on p. 160

Seeds of the Forest

J. D. U. WARD

"How are trees got?" The old forester looked as though he would have apoplexy, and I, feeling sorry for the inquirer, glanced up through the canopy, where the larch cones waved against the blue and white of the sky. The gruff answer, "From seed, of course, like everything else," was perhaps good enough, though in truth some trees are propagated by layering and others—most notably the poplars and willows—by cuttings. But the question itself was in a sense praiseworthy for most people think of trees as 'just happening': *how* or *whence* they have never considered. Since Britain's tentative post-war afforestation programme includes the planting of 3,000,000 acres with trees, at an initial density of about 2000 to the acre, and since the work will be done with public money, the subject of tree seed becomes of general interest.

In the generation of trees Nature is prodigal, as usual, but figures are not astronomical. Good typical one-acre stands of trees have given such annual yields as 850,000 seeds (Scots pine), 4,500,000 seeds (Norway spruce) and 11,500,000 seeds (European larch). A large Douglas fir tree may yield from 50,000 to 180,000 seeds in a good year. A carpet of about 500,000 healthy seedlings to the acre may sometimes be found under beech, a full crop of which will probably show at maturity 100 trees to the acre, the rest having fallen to snails, mice, rabbits, frost, natural competition and the woodman's axe.

But the action of animals does not always work in one way only. Squirrels forget the location of some of the beechmast and acorns which they hide, and a few of the forgotten seeds will grow to be trees. When herds of swine were fed in the forests, their habit of rooting in the ground was recognised as favourable to the setting of acorns, and some smaller tree seeds pass undigested through birds and mammals, even as mistletoe seeds do. Elder and hawthorn are perhaps the most obvious examples in England: the elder to be found in many conifer plantations rises from the droppings of starlings and other birds at roost, and everyone has seen hawthorn seedlings springing up under wire fences on which birds perch. Again there is the story of the spread of nutmeg and mace (mace is the fleshy covering of nutmeg) after the Dutch thought they had established a 'corner' in the tree. The nutmeg tree was supposed to have been extirpated from its native terrain in the Molucca Islands, save only in the Banda group. But then it reappeared, having been carried, it was said, by large pigeons.

Nevertheless, the action of seed-eating animals does not on balance favour the natural regeneration of trees. The failure of most of the early (sixteenth century) plantings of acorns, beechmast and chestnuts in this country was probably due to field mice, and when parts of the Forest of Dean were being replanted in the nineteenth century, after the Napoleonic wars, field mice were so numerous that a bounty was put on their tails. In a single season a hundred thousand tails were brought in. Again, some of the trees which regenerate most readily are not species which we want: Turkey oak is a typical example, and birch and sycamore—both very prolific natural regenerators—might have been mentioned a generation ago, but both these trees have acquired or are acquiring new values because of the development of plywood.

The weights of tree seeds vary enormously: some outstandingly large trees have extremely small seeds. There are about 700,000 birch seeds in a pound; for both alder and Sitka spruce the figure is 200,000; the seeds of *Sequoia gigantea* (*alias* Wellingtonia), the largest tree in the world, number about 90,000 to the pound. At the other end of the scale are oak and Spanish or sweet chestnut, whose seeds run about 100 to the pound. Between the extremes are Douglas fir and Corsican pine, both about 40,000 to the pound, and ash, 6000 to the pound. If comparisons are restricted to seeds of the same species, it may be said that big seeds generally produce bigger plants than small seeds, but the advantage is seldom if ever maintained for any great length of time.

For various reasons, but chiefly because of the damage done by such pests as rabbits, hares, squirrels and deer, relatively few of our forest trees are grown by natural regeneration: more than 90% are hand-planted by man, the young trees having been obtained from nurseries where tree seeds are sown in beds. (Figs. 1–3.) The largest of the Forestry Commission's many nurseries, that at

FIG. 1.—Seed is rolled in at a Forestry Commission nursery. The machine on the left is scattering grit over the seed bed to conserve moisture. (*Picture Post* photograph.)

Tair Onen, a few miles west of Cardiff, contains in its 100 acres some 35,000,000 seedlings and 5,000,000 transplants. (A transplant is a tree which, at the age of one or two years, has been transplanted from its original seedbed to a place where it has more space to grow, both in stem and root, for another year or two before it is planted out in its destined forest.)

Tree seeds vary nearly as much in their viability and the treatments they require as they do in weight. Only 20% of birch seeds can be expected to germinate, and even fewer of the lime or linden will yield plants, but over 80% of oak acorns should develop. Scots pine seed will remain viable, in cone, for at least three years and the seeds of some American pines are said to keep in cone, on their parent trees, for periods of 10 to 100 years. But the seeds of many poplars and willows die within three weeks of release: hence, in part, the practice of propagating these by cuttings. Again, many species of trees yield full crops of seed irregularly: good crops of acorns occur only once in every four or five years, and beechmast is produced in quantity only once in every eight or ten or even twenty years. Conifers are less erratic but are liable to give very little seed in some years.

FIG. 2.—Weeding a bed of two-year-old Scots Pine transplants. These will be planted out in permanent positions in a year's time. (*Picture Post* photograph.)

Sometimes mistakes have been made about the identity of tree seeds. There is the historic instance of the mulberry. When James I wished to establish sericulture in England, he propagated the mulberry for the silkworms to feed upon. Unfortunately the seeds and plants which he distributed were those of *Morus nigra*, and not *M. alba*, which silkworms prefer. Again, mistakes—some may have been intentional mistakes by sellers who profited thereby—occurred in the present century over the hemlocks (*Tsugae*) of North America. The seed of *Tsuga canadensis*, a relatively worthless timber tree, was sold as that of *Tsuga heterophylla* (formerly *albertiana*), which promises to be a valuable accession to our choice of timber trees.

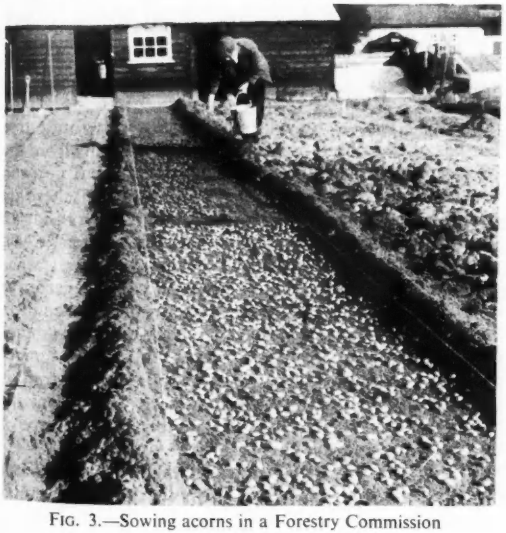


FIG. 3.—Sowing acorns in a Forestry Commission nursery.

The elevation at which trees grow is likely, in many instances, to affect the character of the trees obtained from their seed, even though that seed be planted in quite different conditions more than 5000 miles away. For example, the seed of Douglas fir growing in the lower coastal areas of British Columbia gives much better trees in this country than the seed of trees in the higher inland areas. At present various 'races' of European larch are being studied in detail. Some of the larch seed imported in the past from the Continent has come from too great elevations. In the last year or two there has been concern about the felling of specially good seed trees among the larches in Scotland.

Larches provide an interesting example of an accidental hybrid. About sixty years ago female Japanese larch flowers were fertilised by pollen from adjacent European larches, in Perthshire. The resulting hybrid may in time become a useful addition to our forests. Of course, there are experiments in deliberate hybridisation: particularly valuable work has been done with poplars, which are the fastest-growing of our forest trees, some varieties shooting up as much as ten or twelve feet in a good year. And the propagation of 'sports' is full of possibilities: there is the story of Anthony Waterer's refusal to pay £200 which a collector asked for a bag of *Picea pungens* seed, "from the bluest spruce he'd ever seen". The old nurseryman changed his mind—to his own profit, for he raised from the seed some thousands of seedlings which he sold at half a guinea each.

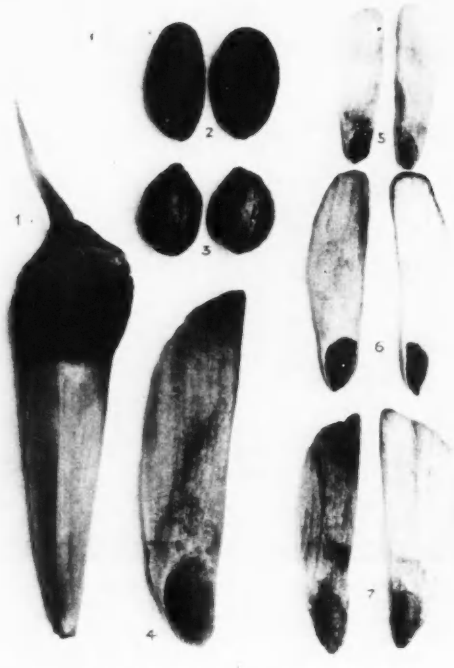


FIG. 4.—A variety of conifer seeds, all natural size. 1, Monkey Puzzle; 2, Stone Pine; 3, Armands Pine; 4, Big Cone Pine (*P. coulteri*); 5, Prickle Cone Pine; 6, Monterey Pine; 7, Maritime Pine.

But true forest trees merit more attention than ornamental varieties. The Sitka spruce is among the most useful of timber trees but once it has flushed in spring it is frost-tender, and in this country the Sitka therefore suffers much damage from April and May frosts. The possibilities of breeding a late-flushing, frost-resistant strain are worth considering, but there are obvious difficulties: as a Forestry Commissioner has recently written, "Wheats, mangel wurzels, or any other quickly maturing plant can be changed out of all knowledge by selection and plant-breeding in a decade or less, but to effect corresponding changes in the habits of trees would take the better part of a thousand years of patient work."* Sellers of tree seed are not required by law to furnish those guarantees of provenance, purity and germination which must accompany farm crops.

Further, our knowledge of genetics, so far as trees are concerned, is very scrappy. We know that seed from bad strains of certain species will usually produce bad trees: the kind of thing that has happened may be illustrated by a paragraph from H. I. Baldwin's book, *Forest Tree Seed*:

> The consequences of international exchange of seeds, fostered by a growing seed industry, are well known from the classic example of Sweden. Artificial regeneration became popular soon after 1800, and in spite of encouragement to local seed collectors, the supply became inadequate. Seed crops are less frequent in the north, and collecting and extracting was not yet well developed. Importations were thus made from Germany, but the dealers in Darmstadt obtained seed not only from Germany, but from Belgium, France, or Hungary. The resulting stands grew rapidly at first, to the joy and pride of the foresters; this joy was short-lived when the good initial growth was succeeded by crooked stems, a sudden thinning of the crown, and the production of excessively long and coarse branches often growing out at an acute angle from the bole.

Again, Sir William Somerville wrote in *How a Tree Grows* (1927):

> It is very important that trees well grown and sound should be used for the production of seed. A great deal of work has been done on this subject of late years, especially in Austria and Switzerland, and it is proved incontestably that the following characters are transmitted from the parents by inheritance, namely: (*a*) the proportion of root to stem. Trees grown at high altitudes develop strong roots so as to be able to withstand gales, and this character is transmitted by inheritance; (*b*) Rate of growth; (*c*) Energy of growth, that is to say whether spread over a short or long period of the year; (*d*) Twisted growth, gnarled and crooked stems; (*e*) Excessive branching of Scots pine is also transmitted in this way. (*f*) Predisposition to leaf-casting is another character which is inherited.

Past carelessness about the provenance of tree seed has brought its proper nemesis with other important species also, most notably Corsican pine and beech, and it is reassuring to know that insistence on seed quality is becoming more general. But it should perhaps be pointed out that the seed from an inherently good tree which is made bad by mutilation or wrong methods of sylviculture is likely to be good, and if there is a badly shaped tree among good trees, in a stand known to be of good origin, then the seed of that bad tree may quite well yield good stock. The problem is, however, complicated: the safest plan is to collect only from trees which have the ideal form aimed at by the forester, namely a straight cylindrical bole and a high-pitched crown.

Seeds of Conifers

The great variety to be found among our forest tree seeds has already been remarked: the gamut runs from the pips of the true apples borne by such trees as crab, rowan and whitebeam *via* the mast of oak and beech (all these are *angiosperms*, that is, the seeds develop and ripen inside an ovary), to the tiny winged seeds of certain conifers, which are *gymnosperms*, the opposite of angiosperms. Since there is a popular tendency to lump all cones together as 'fir cones', it may be well to emphasise that the conifers themselves show a great variety: there are even such things as conifers which do not bear cones: both yew and juniper have fleshy fruits. (The coral flesh of the yew fruit is sweet and good to eat but the hard seed within contains a dangerous poison. The fruit of juniper is the source of both the name and the flavour of real gin.)

Most of the 'fir cones' of common parlance are not fir cones at all, but pine cones. Among the pines we find the heaviest, the longest and the most familiar cones. *P. coulteri*, with cones weighing up to five pounds, would

* W. L. Taylor in *Forests and Forestry in Great Britain* (1945).

be a bad tree to doze under when the cones are falling. *P. lambertiana*, the sugar pine of Western America, has cones which sometimes achieve a length of eighteen inches. Of all cones, those of the indigenous Scots pine are the most familiar in Britain.

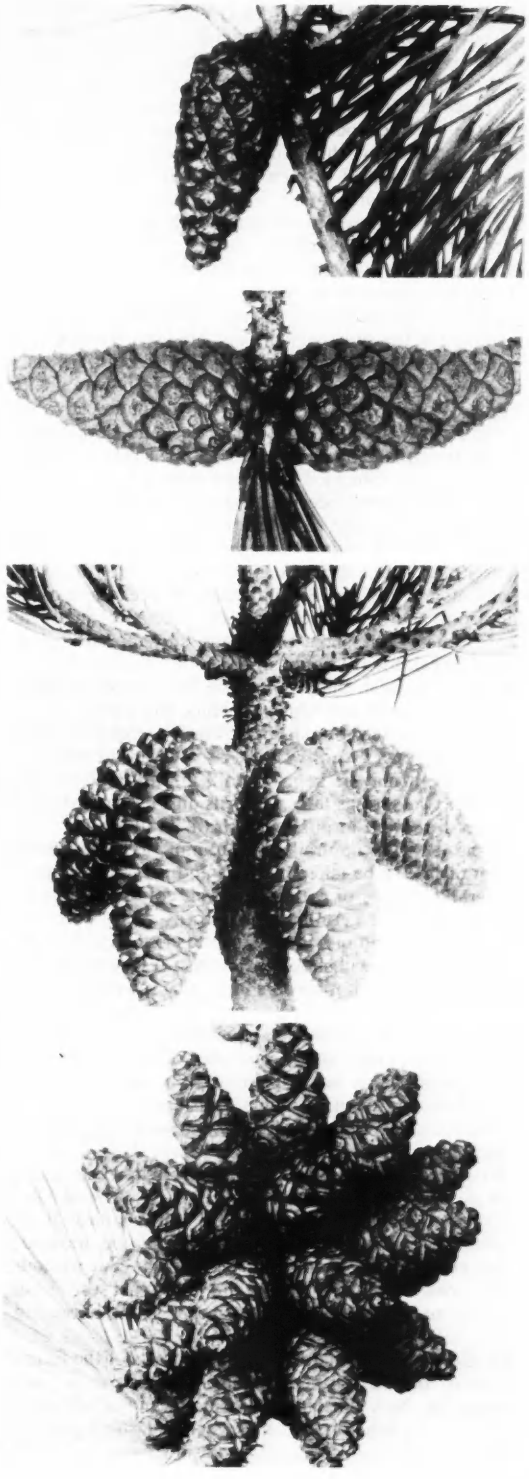
While it might perhaps be said that most cones grow singly, obvious exceptions are provided by such trees as *Cupressus macrocarpa*, *Pinus pinaster* (which is particularly common in Dorset) and *Pinus thumbergii*, the cones of which are in bunches of thirty to fifty. (Figs 5–8.) Most pine cones are compact and relatively heavy for their size, but spruce cones tend to be thin-scaled and light. *Tsuga* cones are among the smallest of all true cones. There is no general rule about the distribution of cones. Some trees (such as the species of *Tsuga*, Scots pine and most cypresses) bear cones on almost any part of the tree, but others (such as the silver firs) usually have cones only on their higher branches.

The structure of cones varies greatly. Scales may radiate from a single point, as in the cypresses, or they may be packed round a central stem, as with pines, spruces and silver firs. Some cones release their seed early (*Thuya plicata* and Douglas fir are examples) but others (such as most pines and spruces) do not usually open until they are warmed by the sun in spring. The cone of the Swiss stone pine (*Pinus cembra*) releases its seeds by rotting on the tree, and the cones of the silver firs, which share with cedar cones the unusual upright habit, disintegrate or fall to pieces in such as a way that only the central core remains, when scales and seeds have gone.

Most pine cones protect the seed within only by the heavy clam-like or armour-plate character of their scales but a few (*Pinus contorta* cones are an example) have sharp needle-like spines. However, such a defence as that avails nothing against a small insect: much of the seed of one of our most valuable forest trees, the already-mentioned Douglas fir, is sterilised by an insect named *Megastigmus spermatrophus*, which feeds on the actual kernel. The damage is such that it is seldom worth while to collect cones for seed extraction from trees grown in this country.

Extracting Conifer Seeds

The extraction of conifer seeds from cones is a business in itself. One of the few large kilns in this country is that operated by the Forestry Commission at Santon Downham in Suffolk. Before the war, 2000 bushels of cones was fair annual average for this station to handle but seed from as many as 15,000 bushels has been extracted in some war years. The cones are put in drawers in a great chest over hot-water pipes. A temperature of 110° F. is maintained. Some cones will open within ten hours, but others need 200 hours in the chest. (Mouldy cones, picked or kept wet, will not open however long they are left. Nor can larch cones be fully opened by heat: they have to be crushed, to extract the seed.) When opened or crushed, the cones are revolved in a machine, so that the seed falls out of them. A normal Scots pine cone contains from 50 to 100 seeds (not all of



Cones of four species of pine. Fig. 5.—Scots Pine (*Pinus sylvestris*) × ½. Fig. 6.—Corsican Pine (*P. laricio*) × ⅔. Fig. 7.—Maritime Pine (*P. pinaster*) × ½. Fig. 8.—*P. thumbergii* × ½.

which will be fertile) and a Norway spruce cone should yield from 150 to 200 seeds. From eight to ten ounces of seed may be expected from a bushel of Scots pine cones.

The liberated seed is next put through two other machines which break off the wings and winnow out the rubbish. During the war the stocks of seed were dispersed, for fear of bombing, but now the seed is stored on the premises in glass carboys, sealed with paraffin wax mixed with red-lead—against mice and rats.

Many pine seeds are attractive not only to rodents but also to Man: notable species include *Pinus pinea*, *P. sabiniana*, *P. torreyana* and *P. cembroides*. Better-known examples of other edible tree seeds are coconuts, beech-mast, sweet chestnuts, hazel nuts, walnuts, almonds, Brazil nuts and the already mentioned nutmegs. Of course, most of our fruits—plums, apples and so forth—are the fleshy coverings of seeds. In the peach we have a fruit developed from the same stock as the almond; with the one, the fleshy covering has been prized and developed, and with the other, the actual seed. Some seeds of forest trees used to be esteemed far more than they now are. A patent for making 'beechnut butter' was taken out in the eighteenth century, and oil is still extracted from beechmast on the Continent, the yield being sometimes as high as 40%. Again, it has been said that 25% of the food of peasants in Italy and Spain consists of bread and cake made from acorns and chestnuts, which are high in carbohydrates. But some tree seeds, such as laburnum and yew, are deadly poisonous.

Most tree seeds in this country are sown in the months of February, March and April, but some authorities advise that Douglas fir seed should be sown in December. Ash seed may be sown green, when it is gathered, in August; alternatively, it may be kept in sand, in a pit, and not be sown until two springs later. Acorns and beechmast may either be stored dry in pits or be stratified in sand.

Acorns if sown 'naturally' in autumn or early winter are more liable to be taken by pests and they also stand a considerable chance of rotting if a wet, cold spell follows the sowing, before germination. Acorns differ from the seed of ash (for example) in that the radicles can be broken off and the acorns will shoot again. Ash seed will not put out second radicles: if it sprouts it must be sown forthwith. The very hard seed of Cobbett's favourite, the false acacia (which is still used in hardwood amenity belts and in a few other positions), is often soaked for ten to thirty minutes in sulphuric acid of about 80% strength, taken out, washed, and sown. Conifer seeds are usually soaked in water for a day or two—Sitka spruce seed is soaked for a week—and then rolled in red lead before they are sown. Larger seeds, such as acorns, sweet chestnut and beechmast (2000 to the pound) are sown by hand (Fig. 3). Smaller seeds may be sown by hand or by a mechanical drill. In special circumstances other methods may be adopted: in our own time tree seeds have been sown—but without much success—from aeroplanes, and in the past seeds have been planted in inaccessible places by discharge—in canisters—from cannons.

We select the seeds required for our forests of the future from most of the northern hemisphere, and even such countries as New Zealand, Argentina and Chile contribute their quota for they have supplied small packets of seed from species of *Nothofagus*—the quick-growing, hornbeam-like Southern Beech. The Forestry Commission's registers include, even in the war years, such entries as 1500 pounds of Sitka spruce seed from Vancouver and 2000 pounds of Japanese larch seeds from Japan in 1941. In 1944 we had beech seed collected in Northern France and Belgium, and a representative was sent out to Corsica to obtain the pick of the Corsican pine seed while the war was still very much 'on'. Seed collections in this country include in one year such figures as 123,019 pounds of acorns and 1816 pounds of Scots pine. 'Amenity' is widely represented: sample figures are 50 pounds of seed from the service tree (*Pyrus torminalis*), 60 pounds of laburnum, 70 pounds of rowan, 36 pounds of spindle. In every instance the figure is for one parcel or collection only, not the total for a year. Pre-war registers recall such oddments as 750 pounds of red oak from Holland, 10 pounds of tulip tree from the U.S.A., 2 pounds of *Ailanthus* from Italy, 2 pounds of *Cryptomeria* from Japan and 2 pounds of *Pinus montana uncinata* from Denmark, besides the more solid items of serious forestry—1345 pounds of Corsican pine from Corsica and 2310 pounds of Sitka spruce from British Columbia.

To the unimaginative the collection, weighing, storage, testing and sowing of all these tree seeds may seem a dull business, very dry and dusty when compared with Shelley's view of the natural process:

> . . . O thou
> Who chariotest to their dark wintry bed
> The winged seeds, where they lie cold and low
> Each like a corpse within its grave, until
> Thine azure sister of the spring shall blow
> Her clarion o'er the dreaming earth . . .

But science has its own thrills and exciting possibilities. We recall how the first *Sequoia gigantea* seeds were collected by a gold-seeker in 1849 and sent in a snuff-box across the American continent by Pony Express, at a charge of twenty-five dollars. We remember the story of David Douglas shooting cones from a great specimen of *Pinus lambertiana* in the West, while the Indians watched, uncertain whether or not to scalp this obvious madman. We recollect what man has produced from wild cereals, wild roses and natural rhododendrons and that he has as yet done relatively nothing with forest trees. Past history and future hopes—the wealth of forests that are, in other continents, and that are to be, in our own country—may be seen in those rows of glass carboys, sealed with red wax, in an old converted henhouse.

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R. H. Richens, *Forest Tree Breeding and Genetics* (1945); Joint publication No. 8 of Imperial Bureau of Plant Breeding and Genetics and Imperial Forestry Bureau.

Two older books contain some reminders of how far or how long the Continent has been ahead of Britain in this field; these are Hichel, *Graines et Plantules* (1911), Baltet, *La Pépinière* (1903).

FAMOUS SCIENTIFIC INSTITUTIONS—I

The National Physical Laboratory

By WILLIAM E. DICK, B.Sc.

AMONG the largest and best equipped laboratories in Europe is the National Physical Laboratory, whose sixteen large buildings and a number of smaller ones cover the better part of the 50-acre site it occupies at Teddington.

Some impression of the scale on which it works may be gained from the Laboratory's gross expenditure. Before the war this amounted to about a quarter of a million pounds—or approximately one-third of the money spent by the whole of the Department of Scientific and Industrial Research, of which the National Physical Laboratory has been a part since 1918. By 1945 the gross expenditure of the NPL had risen to £427,000. These figures do not represent the cost of maintaining the Laboratory to the State. Before the war approximately a third of the gross expenditure was recovered as fees paid by outside bodies and commercial firms for tests and investigations carried out for them by the Laboratory.

The staff of the Laboratory now numbers about 1100.*

The expense of the NPL can be seen in reasonable perspective if one gives a moment's thought to the functions the Laboratory fulfils. Its first function is that of a central bureau of physical standards. J. G. Crowther brings home the necessity of a modern state providing an institution that will safeguard standards in these words: "As the mercantile society of the seventeenth century required accurate astronomical knowledge for the safe conduct of navigation, and founded the Greenwich Observatory to meet its need, the machine industrialism of the nineteenth and twentieth centuries met its need for accurate measurement of the materials of its manufactures by the foundation of the National Physical Laboratory." (*British Scientists of the Nineteenth Century*, essay on William Thomson.) One has only to think of the electrical industry in this connexion to realise that modern scientific industries cannot develop without a 'coherent system of units' and standards for those units. Contrast the modern ease and accuracy with which electrical measurements can be made with the days when "Cavendish was driven to the dire expedient of passing the current through his own body and estimating its magnitude by the intensity of the resulting shock!"† The electrical industry made little progress until practical standards were devised and satisfactory measuring instruments perfected.

The Electrical Division of NPL played an important part in establishing the international system of units which forms the basis of the science of electrical measurement. That work involved a considerable amount of research, an illustration of the fact that research cannot be separated from standardisation.

In its dual capacity as a bureau of standards and a research laboratory of industrial physics, the National Physical Laboratory has paid handsome dividends in many directions. In their book *Industrial Research and Development*, Sir Frank Heath and A. L. Hetherington quote an impressive example of the benefits one particular piece of work in the Electricity Division brought to the industry. "It was proved that buried cables were capable of sustaining greater loads than has previously been thought feasible. As a result of the research conducted at the National Physical Laboratory over a period of years and costing only £80,000, it has been authoritatively stated that the consequent increase in the value to the owners of the cables then laid in the ground was at least £4,000,000, and that at that date the beneficial effect on the annual outlay on new cables amounted to £250,000 per annum."

Estimates of the fuel that can be saved by merchant vessels as a result of improvements in ship design recommended by the Ship Division are also striking. Last year, for instance, it was found that nine of the designs for new ships that were submitted for test could be bettered to the extent that ships built to the improved design would burn 20-25% less fuel than ships constructed to the original design. Allowing for the fact that two or three ships would be built to each design, and adding the estimated saving for some 50-60 other ships to be built to designs where fuel economy of the order of 3-4% could be effected, the annual saving brought about in this one year's work of the Ship Division would be of the order of £70,000.

Services to Defence

Civilisation has moved into an era in which it is not unreasonable to amend Queen Elizabeth's famous remark and make it read "It is upon science that the wealth, safety and strength of the kingdom do chiefly depend." In terms of national security the value of science in general and of a laboratory like the NPL in particular is inestimable. In both World Wars the National Physical Laboratory was called in to deal with many scientific problems. The quality of British military planes has owed much to fundamental aeronautical research carried out in the wind tunnels of Teddington. The introduction into British aircraft construction of Y alloy (the aluminium alloy developed at the end of the 1914-18 war and still used in the last war) rested largely upon intensive studies carried out by the NPL's Metallurgy Division. The designing of jet engines would not have been possible without the work, of the Engineering Division, on the fatigue of metals and their behaviour at high temperatures. Some investigations crucial to the development of radiolocation were carried out at Teddington, and at the NPL's Radio Research Station at Slough. Tests on the models of Mulberry Harbour were made by the Ship Division, the staff of

* In March 1946, there were 755 'non-industrial' employees, including 169 scientific officers; 217 assistant and 224 laboratory assistants (in these two grades there would be 50-100 graduates); 33 artificers (mainly workshop foremen and charge hands). On the administrative and clerical sides there were respectively 6 and 106. The 'industrial' grades, comprising mechanics, labourers and so on, accounted for another 350 persons.

† *The Cavendish Laboratory*, A. Wood, p. 14.

FIG. 1.—Germany's Physikalisch-technische Reichsanstalt, which provided a pattern on which the National Physical Laboratory was modelled. This photograph is of historic interest as the Reichsanstalt was destroyed by bombing during the recent war.

which gave invaluable advice when it came to launching the completed units.

The Laboratory's Origin

The National Physical Laboratory was established in 1900. As it helps in setting the period, it is worth recalling that one finds the first description of the new laboratory appearing in the issue of *Nature* which reported the death of Queen Victoria. In its leader *Nature* commented: "History will for many centuries record the fact that her long reign has been contemporaneous with the most tremendous advances of science which the world has so far seen." The birth of new industries based on those scientific advances had made the setting up of a National Physical Laboratory a necessity. This did not represent the first instance of the State taking part in scientific research, but the NPL was the first laboratory for industrial research to be set up by the Government.

The birth of the NPL was very far from being an instance of spontaneous generation. It had its antecedents (though these were not directly supported financially by the state); there was the work of standardisation and testing done at Kew Observatory, and also 'the determination of the magnitude of certain electrical quantities and their relation to one another' under the direction of the British Association's Electrical Standards Committee. The Board of Trade looked after certain standards, but in general wherever the fixing of new standards required research the work was left to academic scientists and carried out in such laboratories as the Cavendish.

The steps that led up to the formation of the National Physical Laboratory have been described in detail in Sir Richard Glazebrook's lecture that was published in 1933 as a booklet entitled "Early days at the National Physical Laboratory". It is worth recalling some of those details as that booklet is now out of print.

In Kew Observatory by the middle of the nineteenth century there was an embryonic bureau of standards, for besides carrying out its function as a magnetic, astronomical and meteorological station the Observatory tested thermometers, barometers and hydrometers in quite large numbers for the Board of Trade and the Admiralty. Optical instruments were also sent there by opticians for testing. From 1842 to 1871 this side of the Observatory's work was managed by the Kew Committee of the British Association. In 1872 the Royal Society took over its management, and then in 1900 Kew Observatory was incorporated into the National Physical Laboratory.

In the last decade of the century the British Association launched a campaign that was to convince the Government of the need for setting up a National Physical Laboratory. The importance of the British Association's activity in this connexion cannot be overestimated. As Sir Richard Glazebrook once said, "The British Association has done much for British science; its action in promoting a National Physical Laboratory is not the least of its many benefits." The Germans, well advanced in the development of new scientific industries, had established a great State laboratory for physical research—the Physikalisch-technische Reichsanstalt, situated in the Charlottenburg suburb of Berlin (Fig. 1). (This was set up in 1883-87, with von Helmholtz as director.) In 1891 Sir Oliver Lodge used the annual meeting of the British Association as an opportunity for stressing the need for Britain to have a similar institution. In his address, he referred to the work of Kew Observatory and the Board of Trade Laboratory and added:

> But what I want to see is a much larger establishment . . . limited by no speciality of aim nor by the demands of the commercial world, furnished with all appropriate appliances, to be amended and added to as time goes on and experience grows, invested with all the dignity and permanence of a national institution, a physical laboratory in fact comparable with Greenwich Observatory and aiming at the very highest quantitative work in all departments of physical science.

The matter was again raised in Sir Douglas Galton's forceful presidential address to the 1895 meeting of the British Association.

Eventually the Government received a deputation on the subject. The deputation was headed by Lord Lister, as president of the Royal Society, and was representative of the various scientific bodies. A Treasury committee was then set up to examine the proposal. This committee

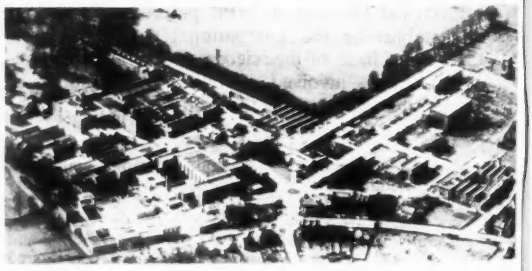


FIG. 2.—An aerial view of the National Physical Laboratory.

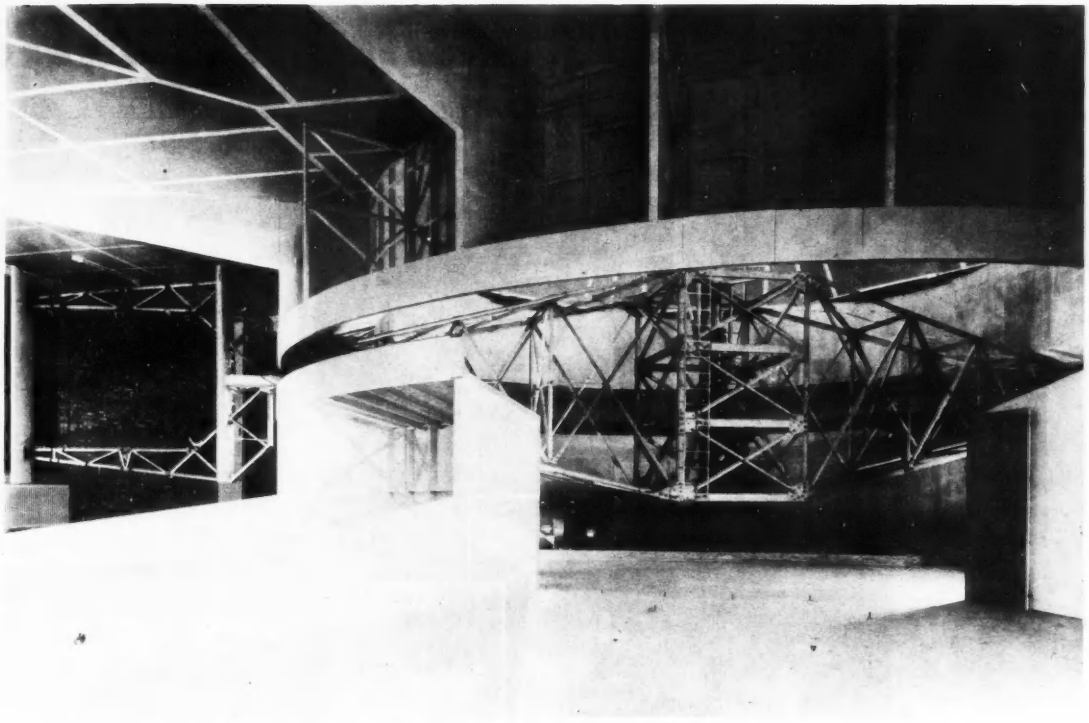


FIG. 3.—The Whirling Arm in the Aeronautics Division. 60 feet in diameter, this apparatus is capable of a maximum rotational speed around half a revolution per second, so that models attached to the frame seen on the left could reach a forward speed of about 100 feet per second. It is used to study the behaviour of aerofoils and aircraft models and components in rotational flight.

consisted of Lord Rayleigh (chairman), Sir Courtenay Boyle (Board of Trade), Mr. Chalmers (Treasury), Sir John Wolfe Barry, Sir Andrew Noble, Mr. Alex Siemens, Professor A. W. Rücker, Professor T. E. Thorpe and Professor Wm. Roberts-Austen.

After taking evidence from some 30 witnesses and visiting the German Reichsanstalt, Versuchsanstalt and Magnetisches Institut, the committee recommended that a National Physical Laboratory should be formed. The members of the committee had come to the conclusion that while in general the Standards Office of the Board of Trade and the Electrical Standardising Laboratories were 'fairly adequate' they would find difficulty over new standards that might be required. Already some standards needed correction; already the Board of Trade was dependent, where more refined standards were required, on investigations carried out at the Bureau International des Poids et Mesures at Paris and by foreign institutions similar to the contemplated National Physical Laboratory. The committee particularly stressed the importance of maintaining close connexion between standards and research. "You cannot separate some research from a Standardising Department" Sir Douglas Galton had told the committee, which expressed the same view in its report.

The model to be followed was the Reichsanstalt. This laboratory had cost £195,000 to establish and its annual expenditure was £15,000. The committee was no doubt wise in saying the NPL should be run 'on lines similar to, though not at present on the scale of' the Reichsanstalt. The Government was asked to make a grant of £12,000 towards the erection of suitable buildings, with an annual grant of £4000 for running expenses.

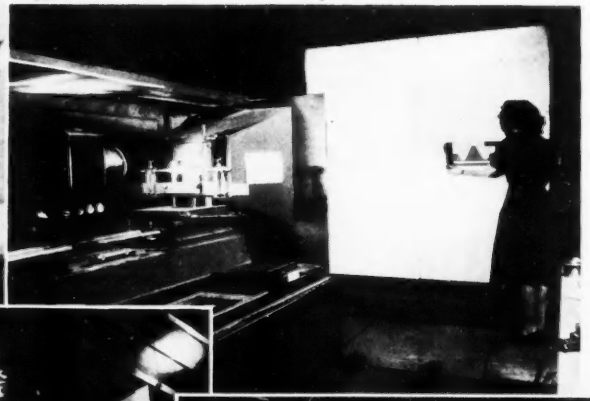
In 1899 the Treasury approved the scheme, and the Laboratory was started in the following year, under the management of a General Board and an Executive Committee appointed by the Royal Society. Twelve members of the General Board were nominated by six of the great technical societies—the Institutions of the Civil, Mechanical, and Electrical Engineers, the Institution of Naval Architects, the Iron and Steel Institute and the Society of Chemical Industry—to give it the 'commercial' representation that was desired.

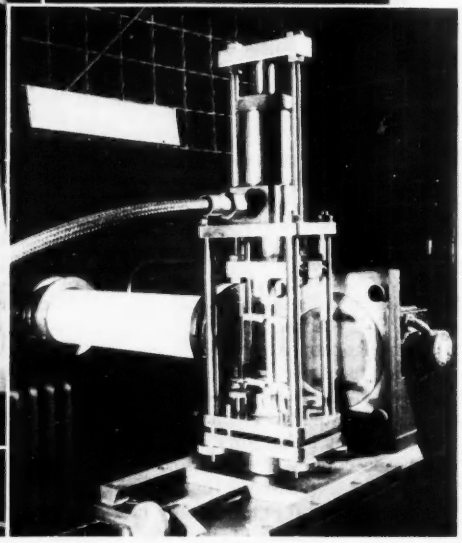
The Executive Committee appointed Sir Richard Glazebrook as first director of the Laboratory.

Originally it was intended that the Laboratory should be installed in the Old Deer Park, Richmond, on a site near the Kew Observatory. But this project fell through and the Laboratory took up residence in the Queen Anne mansion known as Bushy House, the four large wings of which were fitted out as laboratories for electrical and magnetic work, thermometry, metallurgy and chemical analysis respectively. The cellars were converted into constant temperature rooms, and are still in use as such.

Meanwhile Kew Observatory carried on the work of standardisation, and testing was continued there until 1910 (when Kew was transferred to the Meteorological

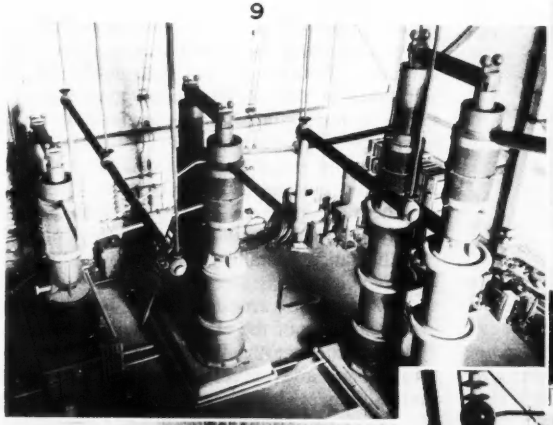
Testing and Reear





4.—The profile projector (Metrology Division). The profile of the enlarged image of a screw is being checked against a standard template. 5.—A metal test piece is inserted into a creep-testing machine; the attached extensometer will measure its changes in length at high temperatures under constant load. 6 & 8.—The Metallurgy Department has added the electron microscope to its equipment. A polished specimen of metal is etched and a cast made of its surface by depositing a plastic film, which is stripped off and examined under the microscope. 7.—This machine shows by means of X-ray photographs the progressive structural changes that occur in a metallic specimen stressed to the point of fracture.

Research at N.P.L.



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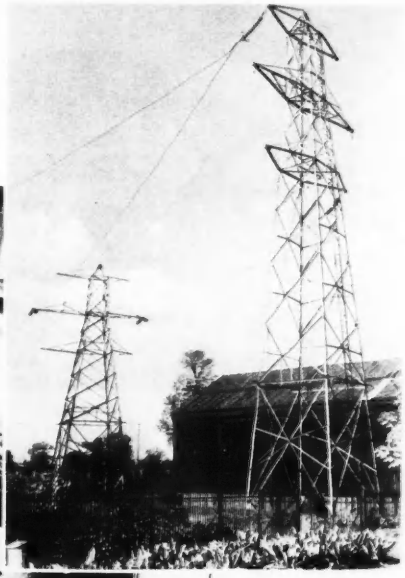

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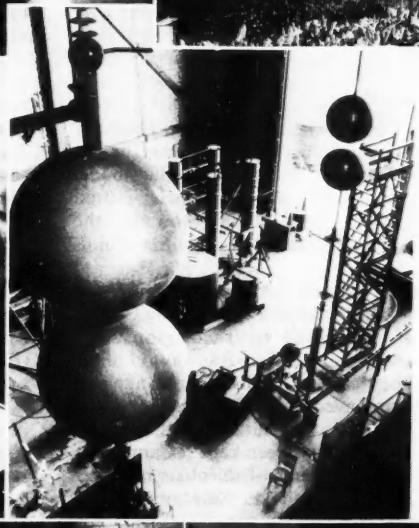

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9.—Three air-insulated high voltage transformers; separately these deliver 375,000 volts when 1000 volts is applied to the primary winding. Connected in series, a voltage of 1,000,000 volts can be reached. 10.—Two standard 'Grid' towers supporting experimental transmission line in the grounds of NPL. 11.—General view of High Voltage Laboratory showing sphere gaps and generator for producing surge voltages of 2,000,000 volts amplitude. 12.—Light Division's high precision spectrometer. 13.—Testing the angular scale of sextants.

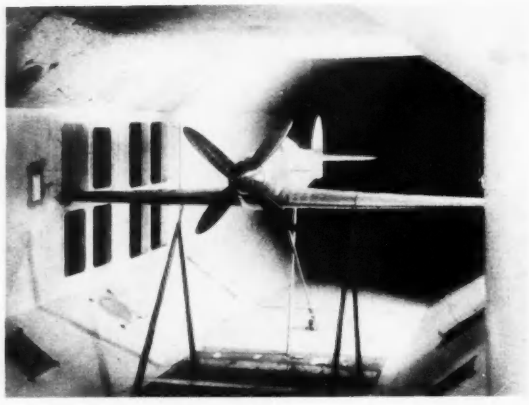


FIG. 14.—Aircraft model in 9 ft. × 7 ft. wind tunnel.

Office, for which it had made meteorological observations ever since 1867).

There was no lack of inquiries once the Laboratory got into its stride. The Navy wanted tests made on its telescopic gunsights. The problem of securing uniform screws for the breech mechanisms of the Army's guns was referred to the Laboratory. The Institution of Naval Architects asked whether a tank could be erected for testing model ships. (Here it is relevant to mention that in the early days a good deal of money came from non-Government sources: thus the Laboratory's first tank for ship-model testing—it cost £20,000—was paid for by Sir Alfred Yarrow. About the same time £10,000 towards the metallurgy laboratory was presented by Sir Julius Wernher.)

The Laboratory was asked to prepare tide tables for India. The testing work of the Indian Engineering College at Coopers Hill was transferred to Teddington. The London Brighton and South Coast Railway inquired whether the Laboratory could make chemical analyses of rails. The NPL received, on loan, the apparatus of the Electrical Standards Committee of the British Association, which had previously been kept at Cambridge.

By the middle of 1900 a nucleus of scientists had been appointed. These included Dr. T. E. Stanton (superintendent of the Engineering Department), and Dr. J. A. Harker, A. Campbell, Dr. H. C. H. Carpenter, B. F. E. Keeling and F. E. Smith, in the Physics Department. Salaries were low, a Superintendent of a Department getting only £400. *The Electrician* remarked at the time the remuneration was not extravagant, adding that "no doubt the duties will be equally light"! But in 1905, and again in 1907, the annual Treasury grant was increased, and salaries were improved accordingly.

In the period 1901-1914, £156,198 was spent on buildings and equipment, of which nearly £56,000 came from private donations. During that time the total income of the Laboratory accounted for £282,545*—scarcely more than the annual income in the years before the late war.

* This sum was made up of: £166,633, fees for work done by NPL; £15,230, donations; £80,500 from the Treasury, and another £20,182 provided specifically for aeronautics research.

The National Physical Laboratory became part of the Department of Scientific and Industrial Research in 1918. After that occurred, the Executive Committee and the General Board were no longer responsible for managing the Laboratory. The function of these bodies is today an advisory one, though in many respects the position is not very different than that before 1918.

In the space at my disposal it is not possible to give a comprehensive survey of the work that the various Divisions carry out. Such a survey indeed would only duplicate what has already been published in the booklet entitled *The National Physical Laboratory: A short account of its work and organisation*, a revised edition of which has just appeared. Some particulars of the various Divisions are, however, necessary to round off this article. ('Divisions', it may be remarked, used to be called 'Departments'.)

There are in all ten Divisions. These are called respectively the Aerodynamics, Electricity, Engineering, Light, Mathematics, Metallurgy, Metrology, Physics, Radio and Ship Divisions.

Aerodynamics Division. 1909 has been described as the beginning of the era of successful aviation. Six years had passed since the Wright brothers had produced their first plane, and aircraft were now capable of flying for more than an hour at one stretch and at speeds of 60 kilometres an hour. It was in 1909 that Britain's need for military aircraft was recognised, and this led to the appointment by the Secretary for War, Lord Haldane, of an Advisory Committee for Aeronautics (which grew into the Aeronautical Research Committee, now the Aeronautical Research Council). On behalf of the Admiralty and the War Office, the NPL was requested to organise at Teddington 'a special department for continuous investigation of questions which must be solved in order to obtain adequate guidance in construction'.

Much fundamental work has been carried out in the Aerodynamics Division at Teddington. Today there are twelve large wind tunnels (Fig. 14) and a whirling arm (Fig. 3) for model experiments which, coupled with full scale experimental work at the Royal Aircraft Establishment at Farnborough, have assisted designers in their task of ensuring the best design of aircraft.

A compressed air tunnel enables the scale effect otherwise obtained with models to be eliminated; this works at 25 atmospheres pressure, and if models of one-fifth full size are tested at air speeds of one-fifth the speed of the full-sized aircraft the Reynolds number remains the same, so that measurements made on the model can be applied to aircraft with safety.

For investigations made at speeds approaching that of sound there are two small tunnels. One of them is of circular cross section (one foot in diameter), and the other has a rectangular cross section (20 inches by 8 inches). Supersonic tunnels are now being designed.

Electricity Division. This division comprises three sections, the *Electrical Standards Section*, the *Electrotechnics Section* and the *High Voltage Laboratory*.

The Standards Section maintains the British legal standards for the ampere, volt and ohm, and also makes calibrations in terms of the international units. In 1940 these units were due to be displaced by a system of absolute units expressed in terms of length, mass and time (a c.g.s. system). This change, which will require international

agreement, is likely to be made soon. Highly accurate radio-frequency standards are maintained by the section, the use of a wavemeter controlled by a piezo electric crystal enabling frequencies to be compared with an accuracy of one part in a hundred million. Before the war standard radio waves were transmitted from Teddington at specified dates and times; whether this service will be resumed is uncertain at present.

Transmission of electricity over long distances has thrown up many high-voltage problems, in the solution of which the High Voltage Laboratory has rendered great service to the electrical supply industry. The laboratory has equipment capable of giving million-volt sparks at power frequencies (Fig. 15) and there is an impulse generator capable of developing two million volts (Fig. 11). In the open there is an experimental transmission line (Fig. 10), and tests made with this apparatus have helped to meet many of the practical difficulties encountered in operating the electric 'Grid'.

Engineering Division. The progress of engineering is greatly dependent on the development of new and better materials and on their correct use. In this connexion the engineer owes a great debt to the Division which has carried out much research whereby materials can be properly assessed and their behaviour in service estimated from the results of laboratory tests and experiments. One illustration of this is provided by the Division's work on the properties of engineering materials at high temperatures. Most important in the production of modern heat engines, particularly the gas turbine used for jet propulsion of aircraft, is the development of materials which will behave satisfactorily at the high temperatures essential for efficient working. Before a new material can be used in an engine, however, extensive laboratory tests on its behaviour under stress at high temperatures are essential. Much work has been carried out in the Division on this subject, and in 1939 a new high-temperature testing laboratory was built and equipped. Nearly every new heat-resisting material used in British aircraft engines during the war were tested in this Laboratory.

The Division has also carried out much pioneer work on the use of small-scale models for the solution of full-scale engineering problems and over 40 years ago wind pressure experiments were made on models of buildings in a small wind tunnel. The observations were compared with the pressure of the natural wind on large plates supported on a tower 50 feet high, and the results have been widely used by engineers responsible for erecting buildings, bridges and other structures exposed to high winds. More recently wind tunnels have been designed and constructed for experiments on models of shells and bullets at air speeds greater than the velocity of sound, and in 1942 a 1500 horse-power supersonic wind tunnel was designed and constructed for experiments on projectiles up to 2 inches in diameter at air speeds up to 2½ times the velocity of sound—about 2,000 miles per hour. Another development has been the use of scale models for the study of ventilation problems in large buildings, and a very recent development of interest to civil engineers has been the construction and use of tidal models for the study of water flow, navigation and silting problems in river estuaries.

The public is well aware of the activities of bomb disposal squads but it is probably not generally known that the equipment used to render bombs harmless by steaming out the explosive originated in the NPL Engineering Division.

FIG. 15.—Million-volt spark.

Light Division. This division is composed of the *Optics Section* (formerly with the Physics Division) and the *Photometry Section* (formerly part of the Electricity Division).

In the Optics Section much has been done on the design of lens systems for optical instruments. All types of instruments and components are tested—telescopes, binoculars, sextants, photographic lenses, polarimeters, colorimeters and meteorological radiometers, for instance. The section was responsible for perfecting a method of specifying colours in terms of three spectral colours, which was adopted, after some modification, by the International Commission on Illumination. The colour specifications which have been prepared are of assistance to many industries: for instance, the colour of the glasses used in railway and road traffic lights, and aerodrome lights, can now be standardised (Figs. 12, 13).

The Photometry Section 'maintains the standard of light of the nation', to quote the words of Sir Frank Heath and A. L. Hetherington. Important researches connected with the lighting of buildings, both by daylight and artificial light, have been carried out, and an extensive programme of investigations has been undertaken on the characteristics of the eye which affect either light measurement or the arrangement of lighting systems. During the war the section helped the Ministry of Home Security to maintain the standard of 'black-out'.

Mathematics Division. This, the youngest of the

Divisions, was set up in 1945. Its work will fall into three categories: computing, statistics, and the development of calculating machines. Recent years have brought considerable advances in the design of calculating machines and in their use. The division undertakes work in this connexion for industry as well as Government departments.

Metallurgy Division (Figs. 5-8). Mention has already been made to the generosity of Sir Julius Wernher, which made the starting of this Division possible. The very earliest metallurgical research done at Teddington was aimed at determining the exact melting point of iron and steels. This made it necessary to perfect methods of preparing pure metals; with iron, for instance, the Laboratory succeeded in devising a process whereby the production of 5-lb ingots of the metal with a purity of 99·985% became a routine operation.

The development of light alloys for aircraft construction owes much to the Division's investigations, and reference has already been made to Y alloy. Important series of magnesium alloys have derived from work at Teddington; some of these have increased strength at ordinary temperatures; others, containing small quantities of cerium and other 'rare earth' metals, retain strength at much higher temperatures than many of the light alloys previously in use.

The metallurgical work of NPL has involved study of manufacturing processes. As many factors, in particular temperature and heat treatment procedure, affect the properties of the product, the laboratory is equipped with pilot scale forges, rolling mills and so on, in which all these factors can be controlled with precision.

Recently much work was done on the production of materials for armour-piercing projectiles

Metrology Division. The measurement of primary quantities such as length, mass and time is the responsibility of this division, which is also concerned with derived quantities, for example, area, volume, density and pressure. A wide range of instruments—engineers' gauges and measuring machines, weights and balances, watches, burettes, hydrometers, barometers—yes, and taximeters! —to name but a few, are sent to the Division for testing.

In the development of gauges for precision engineering the NPL played a leading part. In the words of Sir Frank Heath and A. L. Hetherington, "Measurement has to be an exact science and it has been made so by the work of Whitworth, Johansson and the department of metrology of the National Physical Laboratory". Whitworth was, of course, Sir Joseph Whitworth, whose tool-making concern merged into Armstrong Whitworth, and Johansson was the Swedish expert on precision gauges. At the beginning of the 1914-18 war Britain found herself dependent on imports of ship gauges from Sweden, and it was the National Physical Laboratory which took on the first manufacture of these gauges in this country. Afterwards commercial firms began to make them. The Metrology Division still contributes much to the design of gauges and engineers' measuring instruments and machines.

The Division has done a great deal of work directed towards attaining the objective of making a light wavelength the standard of length. An instrument called a wavelength comparator, designed at Teddington, makes measurement of length in terms of wavelength possible. Using cadmium red light, a yard works out at 1,419,818·24 wavelengths and the metre 1,552,734·44. The development of isotope separation methods in connexion with the atomic bomb project should give the scientists a better source of monochromatic light and so make such measurements more precise—one of the mercury isotopes is considered a likely source. Already a high standard of accuracy has been achieved, as the following illustration shows. In 1934-35 two one-metre standards were measured in Britain and Germany by means of the wavelength comparator; the results obtained in the two countries were found to be mutually consistent to one part in 36 millions, equivalent to an accuracy of one-millionth of an inch in a yard.

Physics Division. This Division is composed of three sections: *Heat and General Physics*, *Radiology*, and *Sound*.

The NPL mark on clinical thermometers must be familiar to all readers, and there is no need to elaborate on this aspect of the testing work beyond a mention of the fact that half a million thermometers are tested at Teddington each year. The division maintains the International Temperature Scale covering the range from −183°C. to 3500°C. and upwards. (A full account of this temperature scale can be found in the Stationery Office pamphlet, *The Units and Standards of Measurement employed at the National Physical Laboratory*.)

The Radiology Section has charge of the British Standard for radium. It is estimated that one-fifth of the world's radium has been tested at Teddington, and the Division has done much to simplify the medical use of its radiation. It is not unknown for hospitals to lose a radium phial, and when this happens an NPL physicist is usually responsible for tracing it. This is not difficult to do with a Geiger counter, but the physicist involved usually gets some publicity in the lay press, for the tracking down of a radium needle seems never to lose its novelty for reporters.

The Sound Section did classic work on the problems of architectural acoustics, and the picture of waves in ripple tanks that were taken at Teddington are now to be found in the most elementary physics books. This branch of the work is carried on in co-operation with the Building Research Station. Today a great deal is known about the transmission of sound through walls and floors, and it is to be hoped that this knowledge will be widely applied in the housing drive so that life in the average house or flat can become less noisome. Incidentally, the Laboratory knows a thing or two about sound insulation. In 1939 air raid sirens were tested in the reverberation chamber at Teddington; though the noise levels inside reached a fearful level (140 phons), the sirens could scarcely be heard outside the building. The noise made by commercial vehicles has been measured for the Ministry of Transport, and the laboratory has already given advice on reducing noise in London's Underground.

Radio Division. The Division is mainly concerned with research for the Radio Research Board of the Department of Scientific and Industrial Research. The Board's investigations are mainly done at Teddington and at the NPL's Radio Research Station at Slough. The Division's work on atmospherics and the cathode ray oscillograph are too well known to require description here. For the Meteorological Office the laboratory undertook the development of the radio sonde instrument, which was

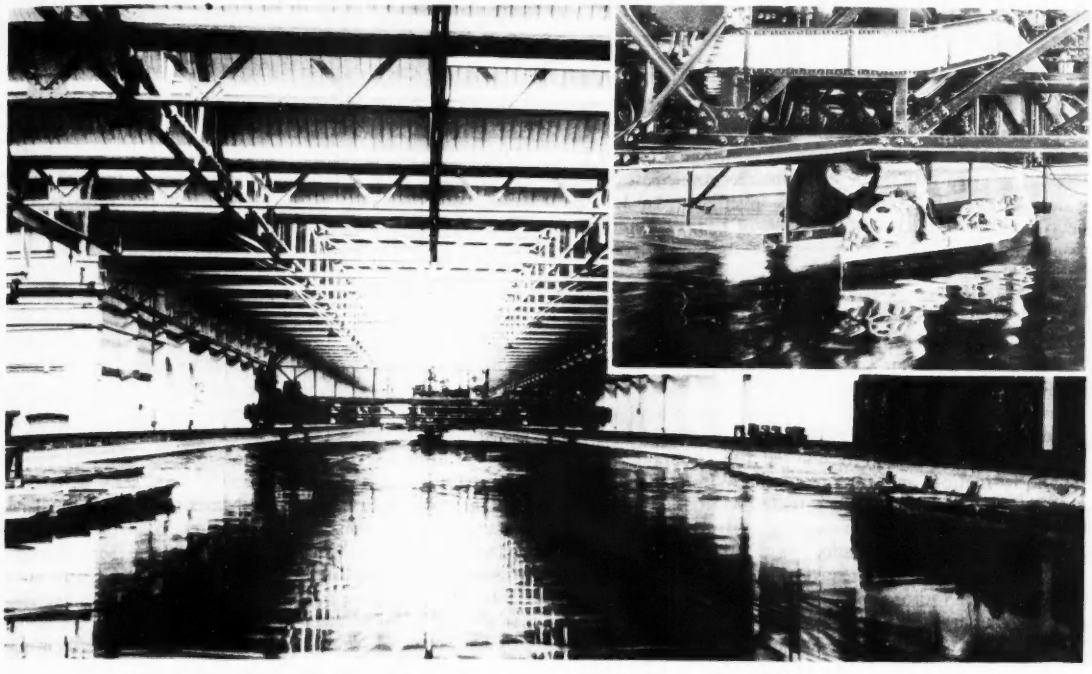


FIG. 16.—The Yarrow Tank, showing the travelling carriage that tows the model ships. *Inset*—A model in position under the carriage, about to be tested for screw efficiency.

an invaluable aid in weather forecasting during the recent war. The Division contributed much to radiolocation.

Ship Division. Outside scientific circles the Ship Division, formerly known as the William Froude Laboratory, is possibly the best known Division of NPL, innumerable articles having been written about the tank work with models—'ships that never put to sea'. The first tank, known as the Yarrow Tank (Fig. 16), which was completed in 1911, is a concrete basin 550 feet long and 30 feet wide, the depth of water in the centre being 12½ feet. Scale models of ships are made in paraffin wax; any desired modification in design is thus easily made on the model by scraping away some of the wax. In testing, the model is towed along the tank and as it moves an automatic recorder notes the amount of resistance which the water offers to progress at various speeds (speed also is automatically recorded). Originally ship hulls only could be tested at Teddington, but in 1919 apparatus for testing propellers was brought into use and experiments with both model hulls and screws became the routine work of the Division. In 1933 Sir James Lithgow gave £5000 to the Division with which a propeller tunnel was added to the equipment. This propeller tunnel is a closed pipe in the form of a vertical pipe 16 feet in diameter, the pipe averaging 3 feet in diameter. Propeller tests are made under varying pressure conditions in order to discover the causes of failure in propeller blades, erosion of blades, and so on. For studying the effect of propeller design, the model ships are now fitted with scale models of propellers which are run by a small half horse-power motor inside the model.

So much testing work was referred to the laboratory that it became necessary to install another tank, called the New Tank, which is 678 feet long, 20 feet wide, and with a depth varying between 2 feet and 9 feet. This tank was finished in 1932.

In the 1914-18 war model work was done for the Navy, in connexion with the improvement of ship design and also on special problems such as those connected with submarine defence nets. Today the Navy has its own research institutions, including the Admiralty Research Laboratory at Teddington, but the services of the Ship Division have been frequently called upon for special problems.

Until recently the work on ships depended to quite a large extent on donations from shipping firms; today the Government provides all the money.

Figs. 2, 3, 14 and 15 are Crown Copyright, published by courtesy of the Director of the National Physical Laboratory.

Fifty Years of Radio-Communication

Lt.-Col. CHETWODE CRAWLEY, O.B.E.

THIS is the jubilee year of radio-communication, for it was early in 1896 that Marconi came to England with his signalling apparatus and, on June 2, applied for provisional patent protection for his invention. In July he gave the first public demonstration of radio-communication by transmitting radiotelegraph messages from the roof of the General Post Office in London to a receiving station on the Thames Embankment.

In the same year Commander Henry Jackson, who became First Sea Lord at the Admiralty in the first World War, was using similar apparatus, which he had developed without knowledge of Marconi's work, for radiotelegraph communication between warships over ranges of a few hundred yards.

In 1897, radiotelegraphy entered the commercial field by the formation, in London, of the Wireless Telegraph and Signal Company, which patented Marconi's invention in all countries, with the exception of Italy where special arrangements had been made.

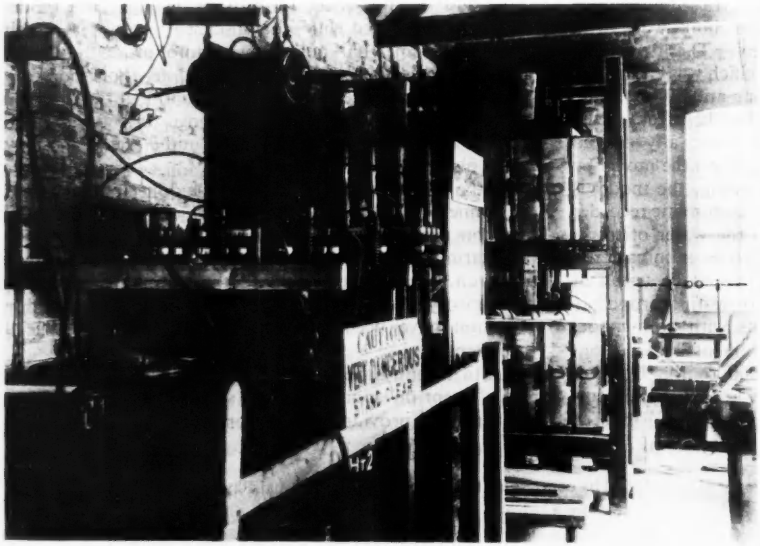
It was clear from the start that the most important application of radio signalling would be for ships' communications and the first ship to be fitted for commercial working was the East Goodwin lightship, which was equipped by the Company in December 1898 for communication with a station at the South Foreland lighthouse. In March 1899 the lightship was rammed by the s.s. *R. F. Mathews*, and assistance was sent as a result of reports from the lightship. This was the first time that radio signalling had been used in connexion with the safety of life at sea. In the same month the Company established communication across the Channel, between Dover and Boulogne.

In April 1900, Marconi filed the most famous of all radio patents—No. 7777, often called the 'Four Sevens Patent'. This was a tuning patent which amplified a patent of Lodge's of 1897 and introduced the idea of a closed tuned circuit coupled to an open aerial circuit similarly tuned for both the transmitter and receiver, It was patented, too, in America and for many years gave a practical monopoly to the Company for tuned systems, both here and in America. This patent gave rise to much litigation but was upheld in the British Court of First Instance, though Lodge's was held to be the fundamental tuning patent, and was acquired by the Marconi Company in 1911 after a seven years' extension.

In 1901, radiotelegraph signals were sent across the Atlantic for the first time when Marconi, in Newfoundland, heard signals consisting of the letter '*S*', from the Company's station in Cornwall. In 1902 he sent the first transatlantic radiotelegram—from Canada to Cornwall.

In 1904, Fleming took out his patent for the two-electrode valve which, after a third electrode had been added by De Forest of America in 1907, was to change the whole technique of radio-communication. This addition to Fleming's master patent was the most important single invention in the development of radio-communication, but it was not until 1913 that the three-electrode valve, with its associated circuits for transmission and reception, became sufficiently developed for commercial use.

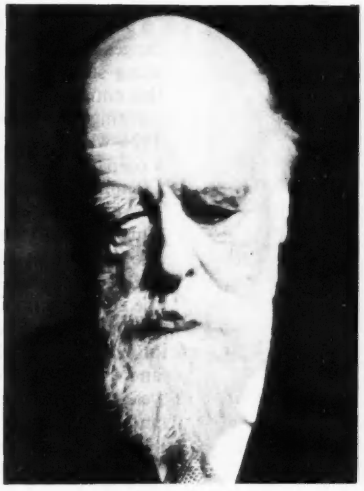
Meanwhile, for reception, the types of coherer which had arisen from Branley's discovery in France in 1890, and were arranged for printing Morse code signals on a paper tape, had been supplanted by other devices which were more sensitive and more suitable for sound reception. The most successful of these were (*a*) *the electrolytic type*, which were first used in 1900 by De Forest and Fessenden in America and by Ferrié in France, (*b*) *the magnetic type*, first used in 1902 by Marconi in England and Fessenden in America, and (*c*) *the crystal type* first used in 1906 by Dunwoody and Pickard in America.



A signal from Marconi's transmitter at Poldhu, Cornwall, was picked up in Newfoundland on December 12, 1901.

On the transmitting side, the original fixed spark gap had given way to rotating gaps first used by Marconi in England; quenched gaps first used by the Telefunken Company and by Lepel in Germany; high-frequency alternators first used by Alexanderson and Fessenden in America, and by Goldschmidt in Germany; and arcs first used by Poulsen in Denmark. The main

Guglielmo Marconi (1874-1937).



Sir Oliver Lodge (1851-1940).

Sir Ambrose Fleming (1849-1945).

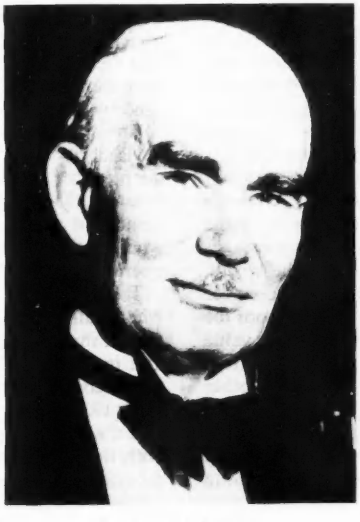
object of all these forms of transmission was to radiate the waves in a more continuous stream than was possible with the old fixed spark gaps. All were in general use throughout the first World War, though on the receiving side valve reception was already being widely used.

The development in transmission towards the use of continuous waves paved the way for telephony. Fessenden claimed to have transmitted by radiotelephony across the Atlantic for the first time in November 1906 when speech between his radiotelephone stations at Brant Rock and Plymouth in America was overheard at his station at Machrihanish in Scotland. Pioneering work in telephony was being done by others too, notably De Forest in America, Poulsen in Denmark and Vanni in Italy, but less was being done in England and Germany where experimenters were more concerned in improving spark systems, which were inherently less suitable for telephony.

In 1907, the Marconi Company opened the first commercial transatlantic radiotelegraph service, between Clifden in Ireland and Glace Bay in Nova Scotia, the forerunner of a host of long-wave services for communication over great distances.

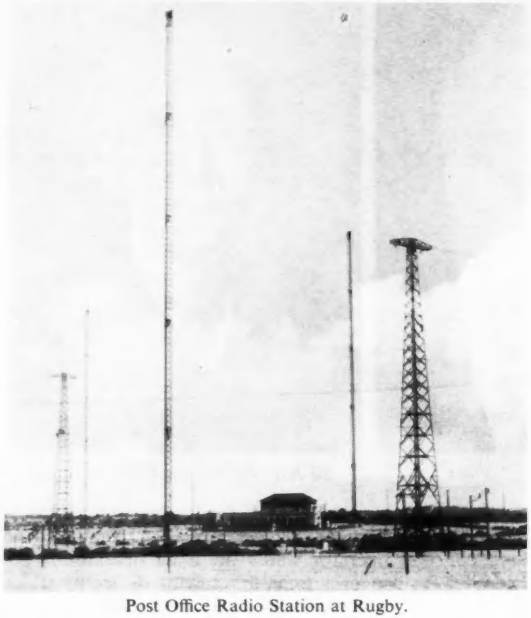
By this year, 1907, the radiotelegraph equipment of ships, using spark transmission, was becoming general for all the larger types of ships. In 1912 the largest ship in the world, the *Titanic*, rammed an iceberg and sank on its maiden trip across the Atlantic, with a loss of fifteen hundred lives. Seven hundred were saved by ships called to the rescue by radiotelegraphy, but possibly all would have been saved if the *California*, which was in the vicinity at the time, had been keeping radio watch. This disaster brought home to the public of every country the immense advantage of ships being equipped with radio apparatus, as well as the serious disadvantage of their not keeping constant watch. As a result, the larger ships of all countries have for many years been compelled to keep constant operator watch or, if an operator is not on watch, to use an automatic receiving device by which an operator can be summoned to the apparatus when a distress call is received. In this last war it was soon found essential to have constant operator watch on all ships, which meant quadrupling the number of operators at sea as the majority of ships carried only one operator, and many small ships were not equipped at all. The number of operators lost amounted to about 1300, a relatively large percentage due to the high tradition observed by ships' radio officers of remaining at their posts to the last in the hope of furthering the chances of rescue for their shipmates.

By 1907 only a beginning was being made with radio-equipment for aircraft, but it was the rapid development of aircraft sets during the first World War that gave a



Dr. Lee De Forest.

J. L. Baird.



Post Office Radio Station at Rugby.

phenomenal impetus to valve technique, especially as regards reception. Much of this work was done in England and France, notably by Round and Ferrié, while in America, which was not involved in the war for some time, great advances took place in the development of valve transmission. The result was that, by the end of the war, valve equipment was ripe for development on commercial services for both telegraphy and telephony.

The first public demonstration of radiotelephone broadcasting was given in America by Fessenden in 1906, using an Alexanderson high frequency alternator, and many more were given in various countries until, in 1919, Izerda in Holland gave a series of entertainment broadcasts, using valve transmission. The Marconi Company started broadcasts from Writtle soon afterwards, and, in 1920, regular broadcast programmes as we know them today were begun in America by the Westinghouse Company. The British Broadcasting Company commenced operations in 1922, and four years later the British Broadcasting Corporation took over the business under licence from the Postmaster General.

In 1926, the first powerful valve transmitting station in the world, erected by the Post Office at Rugby, came into operation for broadcasting radiotelegraph messages on long waves to ships and stations all over the world, and in the following year the world's first long distance radiotelephone service with America was opened from the same station. This Rugby station proved of great value for Admiralty communications in the war, so much so that the Post Office erected for the Admiralty another similar high-power, long-wave station in Wales.

But when the powerful Rugby station was being constructed, amateur experimenters in this country and America were already proving that high power and long waves, hitherto thought to be necessary for long-range working, were by no means essential, and that world-wide ranges could be obtained by small power and short waves, using suitable circuits and under suitable conditions. In this country, Marconi and Franklin had also been experimenting with short waves, and their work culminated in 1924 when the Post Office contracted with the Marconi Company for radiotelegraph communication with the Dominions and India on the Beam System, which used short waves on directional aerials with wire reflectors. This scheme, which was operated here by the Post Office, proved such a resounding success that a merger of cable and radio interests in this country was formed in 1929 under the company now known as Cable and Wireless Ltd. The Post Office, however, continued to develop radiotelephony on both long and short waves at Rugby and other stations, and, when war broke out, this country had for several years been securely linked with America, the Dominions and India, as well as many other countries, both by radiotelegraphy and radiotelephony. Telecommunication services of the British Commonwealth are now coming under public ownership.

Ships' radio-communications had been developing on similar lines. Since 1909 the Post Office had operated the radiotelegraph stations in this country which communicate with merchant ships, and by 1930 had opened long-range radiotelephone services for large ships as well as short range services for small ships, such as coasters and fishing craft. In the war the telephone services were closed down but the telegraph services continued for Admiralty messages and distress working. Over 3500 cases of ships in distress were dealt with during the war. The Post Office also carried out over 40,000 inspections of ships' equipment and arranged for the supply, through civilian schools, of over 10,000 radio officers for the Merchant Navy.

In addition to communication services there has been the development of direction finding, picture telegraphy, television and radar. Suggestions for directional working were made as early as 1899 and some patents were taken out both here and in America, but the first great practical advance was made when Marconi discovered, in 1905, the directional properties of low horizontal aerials. In 1907, Bellini and Tosi in Italy produced a directional aerial system on which many of those now in use are founded, and the present beam systems with reflectors for short and very short waves have developed out of the arrangements used by Marconi and Franklin in 1924.

The first workable system of picture telegraphy was devised by Korn in Germany in 1907 and eventually adapted for commercial radio transmission by Belin in France. The first service between this country and the Continent was opened by the Post Office in 1930, since when many similar services have been brought into operation.

Television as a practical proposition dates from 1926 when Baird gave, before the members of the Royal Institution, the first demonstration ever given of true television, and in 1930 the B.B.C. started the television broadcasts which continued up to the outbreak of war.

In 1935, under the shadow of war, the Air Ministry and the National Physical Laboratory began experiments with the radiolocation of aircraft, and this led on to the far-reaching developments of radar which changed the whole course of events in war and will prove an inestimable boon for the navigation of aircraft and ships in peace.

Army Education in Retrospect

Now that demobilisation is proceeding at a constant rate and large numbers of men and women are being released weekly from the Forces, it may be of interest to consider Army education in the light of its practical successes and failures, writes our Forces Correspondent, who has just been demobilised.

The Army Education Scheme has, one hopes, dispelled the illusion that the British soldier of today is still the beer-swilling illiterate depicted in Kipling's verse. The response from the men to attempts to provide education in the Army has been encouraging in the majority of cases and immensely worth while.

The history of Army education does not, of course, begin with the Army Education Scheme which was launched only in the middle of last year. The Army Education Corps, expanded at the outbreak of war to deal with the large intakes into the Services, has been concerned with the provision of educational facilities throughout the war years. A.B.C.A. discussions and, later, the British Way and Purpose series, were introduced into most units early on in the war with the intention of keeping the serving soldier in touch with the conditions and problems of civilian life. In addition, the A.E.C. ran many excellent courses on current affairs at which civilian experts were invited to lecture. These attempts, good as they were, only skimmed the surface in so far as the success of A.B.C.A. depended in too many cases upon the abilities of the particular Unit Education Officer, while the current affairs courses were normally confined to troops stationed at home. However, the discussions and courses were of value and did prove that adult education was recognised by the Army authorities as a necessary component of military training.

At the end of the war the Army Education Scheme proper was launched. This scheme, designed as a series of pre-demobilisation courses, has already been discussed in these columns and there is no need to recapitulate its aims and organisation. It has been working in most units for nine months or more and its limitations as well as its successes have already become apparent.

It was introduced at a time when the Army was beginning to disintegrate. Instructors are, in consequence, constantly changing, and the wide scope of the scheme has forced most units to abandon any hope of implementing it in full. It suffers from a too elaborate administration; we have encountered many complaints from Education Officers of the time wasted in filling up unnecessary forms and returns. A less ambitious programme and a more flexible organisation would have ensured greater success.

The authorities admit that many units, because of their operational or other commitments, have not been able to implement the scheme. This applies particularly to overseas commands where units are scattered and no central body can be formed to deal with education.

The B.A.O.R., however, has made a very determined effort to put education in the forefront of a programme to occupy the leisure time of troops. Besides the normal trade refresher courses for men about to be demobilised, and the unit schemes for general education, a formation college has been established at Göttingen which, run on the lines of the formation colleges of the home commands, provides advanced residential courses for about 900 students a month. In addition, there are in the B.A.O.R. 30 study centres, mainly in the large towns, which give facilities for reading, discussion groups, literary and debating societies, and many other cultural activities.

The A.T.S. is included in the scheme although the nature of its duties has often prevented women from receiving the full six hours of weekly education to which they are entitled.

In Germany, at least, there is no lack of provision for a serving man or woman who wishes to keep his or her studies up to date, or who is interested in acquiring some new academic interest.

The Far East and Middle East commands do not appear so fortunate. Units are left, in the majority of cases, to their own devices to organise education with inadequate staff and equipment. The climate, the isolation, the absence of contact with European civilisation all militate against adult education.

Yet taking the picture as a whole we must admit that the Army has placed education very high in its programme and has displayed an organising ability which is as progressive as it is unexpected. It has reminded men and women that the acquisition of knowledge is not a trick which a schoolboy possesses only to forget when he reaches manhood but is a course of pleasure which can neither stale nor weary. It has done this in the face of indifference, cynicism, and ignorance.

How has the individual soldier reacted to these attempts to give him adult education? It is fair to generalise to the extent of saying that the soldier is far more interested in social, scientific, and economic problems than the history of pre-war adult education would lead us to expect. The realisation of one's ignorance is the first step towards knowledge, and the great fusion of classes and trades which took place when the majority of citizens put on uniform bred a certain distrust of one's own experience and learning which, up till then, had seemed sufficient. Many men and women became eager, perhaps for the first time in their lives, to know more about their fellows and more about the conditions which governed those lives.

Any lecturer who has visited an Army Unit would probably agree that he has been surprised at the amount of interest he has aroused. Science, history, or economics, nothing failed to stir up some discussion, some expression of a viewpoint, some desire for more information.

The average soldier seems to prefer to have his learning made easy for him—a question more of method than of academic standard. The Army Education Corps has never failed to tell potential educational instructors that they must sell their subject in the same way that a salesman sells his goods. with all the propaganda tricks at their disposal. 'Brains Trusts' are popular because they present facts in an interesting way; quizzes and spelling bees have large audiences for the same reason. The Forces Educational Broadcasts are listened to with interest provided that the speaker can give a lecture which is not simply a dull recital of facts. Sam Lilley's talk on 'Atoms' given in the

[Continued on p. 155

Slavery in Ants

HORACE DONISTHORPE, F.Z.S., F.R.E.S.

Two species of ants in Europe possess the interesting habit of making slaves—the blood-red Robber Ant (*Formica sanguinea* Latr.) and the Amazon or legionary ant (*Polyergus rufescens* Latr.). Only the former of these is found in Britain; but sub-species of both occur in America and possess the same habits.

Before dealing with the life-histories of these two ants, let us briefly consider what slavery in ants really means. It consists of the slave-makers raiding the nests of other ants, chiefly a black and rather cowardly species (*Formica fusca* L.), attacking and killing any of the black workers which may try to repulse them and carrying off their pupae, which are usually enclosed in cocoons, to their own nests; there the pupae develop into perfect insects, and when these adults have emerged from their cocoons they become the slaves of their captors. They clean and feed their masters, their queen, or queens, and their brood (the larvae) and keep the nests tidy and in order.

It is only the worker ants of the slave-makers which carry out the slave raids, and this fact formed one of Darwin's greatest difficulties: to explain why it is that workers, which do not normally breed, inherit the slave-making habits. If, however, he had known, as we do to-day, that the queen slave-maker does not herself found her colony but from the very first steals the *fusca* pupae, his difficulty would have vanished. Thus the workers, of course, inherit this habit direct from their queen mother.

Our first species is a very bold, warlike and active ant. It runs very quickly and attacks fiercely anyone who disturbs its nest, biting very savagely, and squirting formic acid at the foe. It lives in clearings of woods, on heaths and commons, on the outskirts of woods, borders of hedges, and by the sides of roads and paths, and is very partial to heathy land near pine woods. It prefers uncultivated places at a distance from human habitations and disappears before cultivation and the advent of too many people. It was formerly abundant on Hampstead Heath, but that was many years ago.

Its nesting-places are very variable, as it may be found in banks and rotten stumps, under stones, in clumps of grass, in mud walls, and under the roots of heather; small nests may occur under anything lying about.

This ant is very fond of a new nest and in summer it selects open sunny spots, but in the winter it chooses a more sheltered situation. The summer nests have been called 'work-nests' and the winter ones 'rest-nests'. In Britain, at least, it rarely appears above ground before May and often retires in September for the winter.

The summer nests are frequently covered with short bits of cut grass and other vegetable refuse, but these never form a hillock, and make up a carpet only an inch or so high. Very many nests may occur in the same neighbourhood, forming one huge colony.

In this country, at any rate, very few slave raids have been actually witnessed, and by very few observers —Charles Darwin and the writer being two of them.

One of the raids observed by me took place on July 20, 1908, at Bewdley, in the early afternoon. I have described this event as follows: "I found the ants belonging to a nest situated on a high embankment of the railway in a great state of excitement, all running about outside the nest and very active in the hot sunshine, some winged females being also present outside. I then noticed that a lot of the *sanguinea* workers kept arriving, carrying pupae, whilst others were all hurrying off in the opposite direction. These I started to follow, and found they went along the embankment for a good many yards, and then descended the steep bank, crossed the railway lines in a slanting direction, and mounted the bank on the opposite side. At the top I found them busily engaged in ravaging a *fusca* nest. Many workers, laden with pupae, were streaming off in the direction of their home: I had met specimens carrying pupae all the time I was tracking the outgoing ants. Others were attacking and killing solitary *fusca* workers. Several of the latter were observed up the grass-stems, etc., holding pupae and endeavouring to escape from the slave-raiders. I watched these proceedings for a considerable time, and accompanied some of the ants with pupae back to their nest, quite a distance off, though they covered the ground very quickly. Several trains passed but the ants did not appear to be disturbed, as when I went on the lines after one had gone through the ants continued to cross the railway as if nothing had happened."

The exact position of the slave nest must have been previously ascertained by single *sanguinea* workers, scouting independently.

When an expedition starts the leaders keep falling to the rear, others taking their place, and as the ants proceed straight in the direction of the nest to be robbed a number of workers must all know the way in order to be able to lead the others. They must also possess the necessary memory to find the exact spot again. Also, this ant finds its way more by the sense of sight than that of smell.

The fertile female slave-workers may found her colony in the following six ways:

1. With the help of workers of her own colony; by branch nests.
2. With the help of workers of a strange colony of their own species; by the adoption of the female into a strange colony.
3. With the help of grown-up workers of the slave species; by the adoption of the female into independent colonies of the same.
4. With the help of worker pupae taken by force from the *fusca* colony; colony founding by a pupa raid.
5. With the help of pupae of the slave species, which the slave-maker workers had left behind when plundering a slave-nest; colony founding with pupae found.
6. With the help of females of the slave species, when a *sanguinea* female and a *fusca* female find themselves together after the marriage flight; colony founding by alliance.

I have observed the first instance in nature, and have demonstrated, by experiments in the laboratory with observation nests, the possibility of the next five.

The *sanguinea* slave-makers are by no means entirely

dependent on their slaves, for they can feed themselves and their brood and construct their nests, etc. Indeed when a colony has reached its full strength it can get on quite well without any slaves at all. A number of large nests situated near each other and forming one large colony may be found to be without any slaves at all.

This is not the case with the Continental Amazons (*Polyergus rufescens* Latr.), which are entirely dependent on their slaves, being unable to feed themselves, excavate their nests, look after their brood, or do anything of any value for the colony except make slave-raids. For the essentials of food, lodging and education they are wholly dependent on the slaves hatched from the worker cocoons that they have pillaged from alien colonies. Their mandibles are sickle-shaped, and are useless for digging or carrying about the delicate-skinned larvae in the galleries of the nest. These jaws, however, are very formidable weapons; being sharply pointed, they are able to pierce the heads of the slave species.

When at home the Amazon workers do nothing but idle about in the galleries, or spend their time in begging food from their slaves. Their raids are more frequent and more rapid than those of *sanguinea* and are conducted with greater military skill. It has been estimated that one colony of *Polyergus* has made no less than fourty-four raids on thirty afternoons—for some reason or other these slave-raids are only made in the afternoon.

When these ants start a raid they leave the nest very suddenly, moving out in a compact body in great haste. On reaching the nest to be ravaged, they attack in a body, seizing the brood and returning home with them, though not with the same feverish haste they displayed when setting out. When attacked by the slave-species, they often kill considerable numbers of them by piercing their heads or bodies with their sharp jaws.

The nests to be raided have been previously located by single Amazons who leave their own nest one by one and travel considerable distances to search out *fusca* nests, and those of other species from which they steal the cocoons to bring up as slaves. Sometimes little squads of four or five slave-makers may be seen inspecting a nest of *fusca* situated a long way from their own nest. The entrances and surroundings of the nest of the slave species are carefully scrutinised and noted. This individual studying of the slave nests in the neighbourhood of that of the slave-makers enables the raiders to march in a mass straight to the desired spot when a slave raid is started. There is no leader in particular, the Amazon army being headed by a few workers who are being continually passed by workers who overtake them from the rear. This shows that a number of workers know the way, and it also proves that the *Polyergus* workers possess the necessary memory to find the given *fusca* nest which they have previously spotted. Indeed, often the nests to be raided have been selected earlier in the year, and rain and wind, etc., must have entirely obliterated all tracks, or scent, leading to the spot. It can only be memory which directs the ants back to the exact locality desired.

The character of the slaves themselves become changed after being reared in the nests of their masters, and they acquire certain habits, by imitation or otherwise, characteristic of the slave-makers with which they live. Thus *fusca*, which is ordinarily a timid and cowardly ant, becomes courageous and aggressive.

The slaves sometimes prevent the raiders from making an expedition; and at other times they will go out and hunt for any slave-makers which have lost their way, and carry them home. When a colony of *Polyergus* is moved to a new nest, the slaves carry their masters. (The opposite takes place with a *sanguinea* colony when it moves, for under these circumstances it is the slave-makers which carry the slaves).

The Amazon ants nest in the ground, and as they are unable to excavate it themselves it is constructed by the slaves. It is probable that to found a colony a young *Polyergus* female, as she is unable to do so unaided, not possessing domestic habits, enters a *fusca* nest, is accepted, and eventually kills the *fusca* queen, if present. The *fusca* workers then bring up her brood. The mixed condition of the colony is kept up by the slave-raids, which are continued as long as the colony exists.

It has been proved by experiments in observation nests that a *Polyergus* female will easily be accepted by *fusca* workers. It has also been shown that when a *fusca* queen is present the Amazon female eventually kills the *fusca* queen and is accepted as queen in her place.

ARMY EDUCATION IN RETROSPECT—*Continued from p. 153*

form of a dialogue on the subject is an excellent example of the method which can be adopted to entertain and instruct at the same time.

What future is there for adult education? Will the soldier return to civilian life, fit himself into his groove of usual interests, and forget that he is still a member of a community with the obligations and problems which living in a community entails? Will he lose the aptitude for absorbing information on subjects for which he had previously shown no interest, principally because he had little opportunity for studying them?

The answer to these questions depends primarily upon the individual. Once a man or woman has discovered an interest in education it is unlikely that he or she will ever abandon it entirely. It is interesting to note, in this connexion, the civilian bureau for current affairs which has been formed recently by Mr. W. E. Williams, formerly director of A.B.C.A. Its aim is not to start fresh discussion groups in factories, clubs, and villages, but to provide these groups with up-to-date information on current affairs, with map reviews, pictorial aids, and special courses for group discussion leaders. This body, the civilian successor to A.B.C.A., has no doubt that the discussions of current affairs which filled so many hours in the Army have become a permanent feature of civilian life. Certainly it is an experiment worth making and should have an important effect on the creation of an informed democracy. Whether Britain will ever see colleges for adult education on the same scale as those of Denmark it is too early to say.

The Army has opened the gates of learning to a body of men and women who through circumstance, lack of opportunity, or lack of interest, were previously excluded. Let us hope that as civilians they will insist that the gates shall remain open.

The Bookshelf

General and Inorganic Chemistry for University Students. By J. R. Partington. (Macmillan, London, 1946; pp. 916, 36*s*.).

PROFESSOR PARTINGTON has given us another text-book. This is an old and trusted friend, his well-known *Text-Book of Inorganic Chemistry for University Students*, in a new guise. The subject matter, more advanced, is brought up to date, even to the inclusion of a paragraph on the atomic bomb.

A new and improved arrangement divides the work into two. After an introduction in which the history of chemistry is summarised in just over ten pages of close print, Part I takes us from the laws of conservation of mass and chemical combination through chapters on atomic and molecular weights, the kinetic theory, the phase rule and solutions, thermo- and electrochemistry, the law of mass action, electrolyte equilibra, the periodic law, modern atomic theory, the solid state, to the quantum theory of the atom. Part II, the larger section of the work, describes the inorganic chemistry of the elements and their chief compounds, and, as one expects from a writer of Professor Partington's calibre, the work of revision and modernisation has been well done.

A new and welcome feature of the book is the inclusion of a list of works of reference, and references in the text itself to original papers to which Honours students and older readers can turn for further reading. The text dealing with the platinum metals, with molybdenum, tungsten, uranium, titanium, zirconium, hafnium, thorium, niobium and tantalum has been adequately expanded for a text-book of this scope, and in keeping with his views that the history of chemistry should not be neglected by the student, the author has not hesitated to incorporate many notes and facts of historical interest in the text.

Professor Partington's high reputation for accuracy in the presentation of fact tempts reviewers to make a special search for errors, and they will find one in the statement (p. 530) that "TiO_2 is also formed when K_2TiF_6 is heated with concentrated sulphuric acid," and another under 'Chlorine', p. 770, where he says "All products obtained from oxymuriatic acid weigh more than the gas." Here, he has forgotten hydrogen chloride, a lighter gas and a simple product of chlorine with another element. There is inconsistency, too, in the statements (pp. 379 and 382) concerning the solubility of barium sulphate in acids. Misprints appear to be commendably few in number.

The weakest part of an otherwise excellent book is the index. The method of grouping the compounds of an element under one heading undoubtedly saves space, but it does not make for ease and speed of reference. Uncertainty arises under the heading 'perborates' where the incautious reader might imagine that perborate-carbonates and perborate-vanadates exist and are described. Finally, there are many compounds, some of those of selenium, molybdenum, tungsten, and platinum, for example, which are dealt with in the text, but this is not to be realised by a reference to the index. Professor Partington could increase our debt to him by giving every compound that he mentions a line to itself in the index. Much, if not all, of the extra space needed for doing this could be gained by deleting the instructions given for some of the experiments, many of which are too elementary to be retained in a work of this kind.

The book is a masterpiece of condensed writing; indeed, some teachers may find it too condensed for extensive use in schools, but for the Honours student in a university it will serve as an invaluable companion to his studies. The book is, as the author rightly tells us, "intended for students who are keenly interested in Chemistry", and they and their teachers should be grateful to him for writing it.

L. S. THEOBALD

The Cavendish Laboratory. By Alexander Wood. (Cambridge University Press, 1946; pp. 59, illustrated, 2*s*. 6*d*.)

ADEQUATE histories of the Cavendish exist and, while not entirely up to date, they do cover most of the material. But this booklet, providing a sketch history in 11,000 words, is on the whole more interestingly written than any previous work on the subject. In some respects it is better balanced than some of the earlier expositions. For instance, there has been no artificial hiding of the perfectly natural fact that much of the earlier work of the laboratory was done for extremely practical purposes.

Occasionally brevity leads Dr. Wood into formulations that do not give the fairest representation of the facts. For example, in the work that established the 'sun-and-planet' structure of the atom, Rutherford's contribution was mainly theoretical. The experiments that prompted his theories were the work of others; but the book gives the impression that they were made by Rutherford. It is regrettable that there is no index. Apart from these minor criticisms, the book is well balanced and easy reading. S. L.

Atomic Artillery and the Atomic Bomb. By J. K. Robertson. (Van Nostrand, New York, 1945; pp. 173, 12*s*. 6*d*.)

THIS is a revision of a book published in 1937 under the title *Atomic Artillery*. The advent of the atomic bomb prompted the production of the present edition, with the addition of the appropriate post-1937 material, but with little change in the original. This expedient leaves its mark; the new and old do not always dovetail as they should. The additional sections are not nearly so well written as the original, and whereas a great deal of trouble was taken in the earlier sections to use every possible device to make matters easy for the lay reader, the material on fission and its consequences is assembled with much less care.

The political and moral questions raised by the atomic bomb are mentioned in the closing pages, but no important contribution is made to the discussion. Therefore the book must be judged by whether it expounds the scientific questions in the way that is most helpful to the layman. Apart from the hastily written additions it reaches a quite high level in this direction. It is, for example, a happy metaphor to illustrate the quantum nature of light in terms of waves on a lake with the supposed property that a stone thrown into it could upset a boat on the farther shore.

There are occasional lapses. It is not satisfactory to 'explain' how electrons and positrons are produced by a nucleus supposed to consist of protons and neutrons only, in terms of the idea that when a conjurer produces a rabbit from a hat we do not believe that the rabbit really was in the hat. Sometimes there is an unnecessary search for striking phrases that may be merely confusing. "Protons exist only when travelling at the speed of light" means no more than, and is less clear than, "Protons travel at the speed of light."

But in general the exposition is clear and careful. The field covered is wide, wider perhaps than would have been the case if the whole book had been written with the atomic bomb in mind—and this may be a decisive point in its favour. S. L.

Atomic Energy for Peace and War. By N. C. Turner (Oliver and Boyd, Edinburgh, 1946; pp. 35, 1*s*.).

CLEARLY there is a spate of books on atomic energy to come. British authors have been slow off the mark, but the number of such books is increasing. At the moment few British authors are as up to date as the Smyth Report. This booklet does take cognisance of that report and is adequate for its size. Written at a popular level it does not entirely succeed, in that the author finds it necessary to introduce such unessential technicalities as K, the multiplication factor involved in fission. Diagrams would most certainly have improved the book, and it is a pity that none is included. This reviewer was unfavourably impressed by two points: firstly, it is a waste of paper to have a one-page foreword in a booklet of 35 pages, and it is deplorable for the publishers to deface a pamphlet costing 1*s*. with the words "Complimentary Copy—Not for Sale."

WM. E. DICK

Good Health to the Garden. (Plant Protection, Yalding, 1946; pp. 48.)

THIS booklet explains and illustrates the commoner diseases and pests of vegetables and their control. In the latter part of the booklet a few common garden weeds are illustrated.

Although it is well printed on good paper and has good colour illustrations by Dorothy Fitchew, the booklet in the space of its 48 pages does not aim to be more than an introduction to the subject.

Two Films on Personnel Selection

RONALD MacKEITH *and* DEREK STEWART

DURING the war British military needs demanded an efficient distribution of the limited man-power available in these islands. The Army in particular could no longer afford the peacetime methods which often resulted in the placing of 'square pegs in round holes'. It became necessary to estimate the physical and mental capacity and character of each man and to calculate his usefulness for a particular job. Early in 1942 the Army instituted a method of selection to achieve this proper placing of recruits. A new method was also adopted for finding those likely to make good as potential officers, and eliminating those who would be unlikely to pass successfully through the OCTU course or to stand up to the responsibilities and strains which an officer has to shoulder. The originality of these new methods of selection lay in the use of trained psychologists and psychiatrists. For example, in the case of officers, the President of the Board, with whom the decision of acceptance or rejection remained, not only interviewed the candidates and received reports from military officers observing the capacity of candidates under practical tests, but also heard the opinions of psychologists and psychiatrists on the intellectual capacity and personality of each candidate.

This use of psychology for fitting men into the Army proved a most successful large-scale example of the use of the social sciences which can have far-reaching effects on the solution of future social problems; and it is most satisfactory that the Ministry of Information should have expounded the technique used in two excellent films: *Personnel Selection—Recruits* and *Personnel Selection—Officers*, both films being made specifically for showing to audiences with a specialised interest in the subject. The first was completed and shown last year and the second has just had its premiere. Both films are directed by Geoffrey Bell who—since his description, in the film *Control Room*, of Bristol's A.R.P. Services—has been developing quite a new film method of objective exposition, and it is important to consider them as complementary.

It is no easy task to make an accurate film of an industrial process even though the various techniques and occurrences are factual and exist in a physical sense. What these films on personnel selection have to show are largely mental and not physical reactions, and herein lies the brilliance of the success achieved, for they are among the very best scientific expositions presented by film. With an amazingly complete grasp of the intricate subject, Bell has produced two most lucid, balanced and fascinating films.

Viewing *Personnel Selection—Recruits* is like reading a well-written and illustrated technical report, in which the subject matter is interesting but needs concentration. The various tests in the analysis of a recruit's capabilities are clearly explained and the personal interviews with the selection officers are interesting and natural. The diagrams and charts are particularly good in their clarity and layout, although some must have caused a few headaches over the number of figures to be shown. The film also shows a tantalisingly brief glimpse of the impressive Hollerith punched card machines which sort out the millions of men into the required trade and task groups.

Personnel Selection—Officers follows the same pattern and here the subject matter is more personal and interesting, and the direction more sensitive. A group of eight candidates is followed from their arrival at the WOSB (War Office Selection Board Unit), through their three-day stay. All are treated as officers and every effort made to make them feel at their ease. This helps them to be natural and makes it easier for the Board to find their capabilities. A draft estimate of the personality is made from written answers to a number of questions. Under the observation of Military Training Officers, the candidates—in groups or singly—are faced with a series of problems and obstacle races requiring a combination of mental and physical skill and judgment. At other times discussion groups are formed and unobtrusively watched by members of the Board. While showing the group in its tests, the film skilfully builds up special interest in the characters of three particular candidates. On these three the Selection Board feels that more information is required than can be obtained from the written and field tests and the psychiatrist is asked to see them. Two spontaneous and unrehearsed psychiatric interviews are shown. The friendly and unhurried atmosphere created by the psychiatrist is brilliantly conveyed by the director aided by a most natural performance by the psychiatrist, a non-theatrical Sydney Greenstreet.

The film makes good use of diagram to give a grasp of the whole process and comment should be made on the good sound recording; the natural sounds of birds and bombers overhead lend considerably to the reality of the film.

Though made for specialised audiences, these two films should be seen by all who appreciate exceptional filmcraft and by all who are interested in the application of the social sciences to everyday problems.

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This diagram from *Personnel Selection—Recruits*, which in the film is built up cinematically, piece by piece, indicates how jobs in the Army are divided into broad categories according to the different physical and intellectual demands they make on the man. Such a scheme guides Selection Officers and ensures that a recruit is not given work for which he may lack the minimum ability in any sphere. A signaller, for example, can be slightly below average intelligence (3 –), but he must not be less than 3 + (slightly above average) in his ability to handle words and figures. In the top line *TR* stands for "Training Recommendation", and "Inst", heads the vertical column giving minimum marks for the test designed to measure ability to carry out instructions. *SG* is "Selection Group". Since the film was made in 1944 the table has been adjusted to meet new conditions.

Far and Near

A Key to Longer Life?

A LONGER, healthier life may become possible if results obtained with experimental animals are confirmed by clinical tests. This point was made by Dr. Thomas S. Gardner, in a paper read before the Biological Division of the American Chemical Society on April 11.

Yeast nucleic acid (ribose nucleic acid) has been tested on animals and has increased their average life span as much as 9% besides making them stronger and more active, said Dr. Gardner, who added that the process is ready for experiments with human beings. "If clinical tests indicate good results for people, as well as for mice, yeast nucleic acid will eventually be added to the roster of treatments designed to make people healthier and enable them to live longer," he added.

Dr. Gardner's work was a continuation of that started in Australia several years ago by the late Dr. T. B. Robertson, who found that the life span of white mice could be increased by about 15% if they were fed large amounts of various nucleic acids from birth, in addition to an adequate diet. Dr. Gardner used ribose nucleic acid as it is the only nucleic acid that can be produced in bulk at a low price.

These researches derived from the theory that they were built into the nuclei of the body cells. Dr. Gardner postulated that nucleic acids might increase the internal resistance of the body to breakdown, and also spare the essential nucleoproteins in the cells during metabolism. If this were true much smaller amounts of nucleic acid than Dr. Robertson had used would be beneficial. Accordingly, Dr. Gardner used one-tenth as much nucleic acid as had been employed by Dr. Robertson on albino mice.

"In order to test the benefits on older animals, only mice over 600 days old were utilised," he explained. "This age roughly corresponds to about 60 years in human beings. I found that I was able to increase the average life spans about 8-9% over the control animals. The male mice responded slightly better to the treatment than the female animals. In all my tests I obtained healthier and more active animals by yeast nucleic acid treatment, as well as longer average life spans."

There have been only a few compounds discovered that hold out a promise of longer life for man, Dr. Gardner pointed out, recalling that years ago Dr. Alexis Carrel and Dr. A. H. Ebeling of the Rockefeller Institute for Medical Research showed that ageing was a chemical process and could be affected by appropriate treatment. In one experiment, he said, Dr. Carrel withdrew blood from the body of an old dog, separated the blood plasma from the blood cells, washed the cells and reinjected them back into the dog's body in an appropriate solution. The dog was rejuvenated, grew a new coat, regained agility and vitality and acted like a young dog, although the rejuvenation gradually wore off as the old cells in the dog's body affected the purified plasma. Unfortunately, Dr. Gardner said, this work was not followed up.

In Russia, he continued, Professor Alexander A. Bogomolets has developed a serum said to increase the internal resistance of the body. The Russians assert that their anti-cytotoxic serum (A.C.S.) will increase the life span of men to 120 years, but not enough time has elapsed to prove or disprove this contention, he noted.

Patent Reforms Proposed

THE Departmental Committee appointed by the Government to examine patent law has published its second interim report (Cmd. 6789). Among the questions which witnesses were asked to deal with were two important ones—"Complaints have been made that British patents are used to the detriment of the public interest, for forming cartels and retarding competitive developments, etc. Do you consider these complaints justified?" and "What is your view as to the effect that it (endorsing all patents 'Licences of Right') would have on the flow of patents, on the commercial exploitations of inventions, and on the retention of inventions as secret processes?"

The Committee refers to the frequent allegations of deliberate suppression of inventions, but states that "in spite of our endeavours to obtain it, no satisfactory evidence of particular examples has been forthcoming. Several persons who had made public statements about the suppression of invention were invited to give evidence but did not accept the invitation. We have formed the opinion that this type of restriction has been much exaggerated."

Patents, the committee holds, are often a means to the maintenance of monopoly by cartels, but "no conceivable reform of the patent system, nor even its total abolition, would by itself solve the problem of monopoly in modern industry". The committee considers that it obviously is desirable that the patent law should keep in step with any measures which may be adopted in the future to limit or control monopoly in the public interest. Prohibitive cartel arrangements have come to light during the war, says the committee; the report instances the case of atebrin and other drugs marketed by I. G. Farben, and adds that "arrangements having a similar effect between British and American firms for the supply of machinery and equipment are believed to exist."

On the subject of 'Licences of Right', the committee reports that in spite of the advantage to a patentee of a reduction of one half of the renewal fees on a patent endorsed 'Licences of Right' only about 5% of patents have been so endorsed, of which only a very small proportion result in the grant of licences. Moreover it is not unusual for a patentee to apply for cancellation of the endorsement. The section of the Patent and Designs Act appears to be one in which patentees have perhaps not much confidence. Section 38A, designed to prevent monopoly abuse of patents on food and medicine, has only been applied, effectively, once since 1919. Strengthening of the law is advocated in this connexion.

The committee finds that the existing directions to the Comptroller of Patents as to how he shall exercise discretion in settling the terms of a licence are unsatisfactory. With regard to patent applications that lack subject-matter, which the Comptroller has no power to refuse at present, the committee feels that the position is far from satisfactory. "People are deterred by the risk of legal proceedings from attempting to manufacture articles forming the subject of a patent, however obvious it may be that the patent is invalid. Moreover, the present system tends to encourage the proprietor of a valuable patent to take out subsequently a number of subsidiary patents for trifling improvements or modifications of his invention, thereby obtaining an unjustifiable extension of the period of protection." The committee make recommendations calculated to reduce the proportion of applications lodged for these trivial and spurious 'inventions'. There is little ground for apprehension, adds the report, that inventions of real wealth would be rejected if the Comptroller had the extra powers necessary. Rejection for lack of subject-matter is already legal in the U.S.A., Germany, Sweden and Holland.

I.C.I. Chemical Exhibition

AN exhibition of British chemical research will open in London in the first week of June. The exhibition is being organised by Imperial Chemical Industries, and is designed to demonstrate to the public how, under the stimulus of war, British chemists made discoveries of permanent importance to mankind. The exhibition will be held at the Tea Centre, Lower Regent Street (corner of Jermyn Street), London, S.W.1.

Science on the Air

ON May 3 in the Light Programme the first number of 'Science Survey' was heard. The B.B.C. claims that this series of broadcasts will be "the most comprehensive attempt made so far to put science on the air." Every Friday from 6.30 to 7.0 p.m. scientists themselves will talk about the work with which they are concerned in a simple straightforward way, suited to the needs of the general public. Professor E. N. da C. Andrade has agreed to act as scientific director of the series. The programme will be repeated in the Home Service the following Wednesday at 10 p.m. The producer is Ian Cox.

Normally the programmes will be made up of items from two or three speakers representing different branches of science. The first 'Science Survey' was introduced by Sir Robert Robinson, President of the Royal Society, and by Sir Edward

Appleton, Secretary of the Department of Scientific and Industrial Research.

It is hoped in the following three weeks, under the general subject heading of 'Work in Progress', listeners will hear, among others, Professor Andrade talking on some aspects of atomic energy; Professor D. Brunt on recent research in weather problems; Dr. S. L. Smith on problems of ship-building; the Astronomer Royal on sunspots; Professor W. T. Astbury on fibres; Sir Percival Hartley on penicillin and Professor A. O. Rankine on oil prospecting. After that there will be a programme devoted to scientists at work, in which it is hoped that Professor Andrade and Sir Robert Watson-Watt will describe a typical day's work, and talk about research that they have done. In the sixth week Professor Andrade will go round the National Physical Laboratory and introduce scientists at work. These recordings will be made on the spot at Teddington.

An 'Any Questions' section will be introduced into 'Science Survey.'

This month a conference on science and the B.B.C. is being held at Cambridge. We hope to publish a report on it in the next issue.

International Control of Atomic Energy

THE British Stationery Office published last month the most important document on atomic energy that has appeared since the Smyth Report. It is a reprint of *A Report on the International Control of Atomic Energy*, drawn up by a 'board of consultants' to the U.S. Secretary of State's Committee on Atomic Energy. The five members of the Board were Dr. J. R. Oppenheimer (formerly in charge of the Los Alamos atomic bomb laboratory), Dr. Chester Barnard (president of the Bell Telephone Company), Mr. David A. Lilienthal (chairman of the Tennessee Valley Authority), Dr. Charles A. Thomas (of the Monsanto Chemical Company, which co-operated in atomic bomb development), and Mr. Harry A. Winne (vice-president of the General Electric Company, which was concerned with electromagnetic separation of U235 in connexion with the atomic bomb project).

The report, which costs a shilling, will receive comment in next month's DISCOVERY.

Britain's Atomic Energy Bill

THE Minister of Supply introduced the Atomic Energy Bill in the House of Commons on May 1.

Russian Science Films

DURING the last few years several notable Russian films on scientific subjects have been sent to this country. Two of the most recent arrivals were shown on April 9 by the Society of Cultural Relations with the U.S.S.R. Both dealt with natural history. The first, *Island of White Birds*, depicted the bird life on a floating island of reeds, and the second, *The Sunny Tribe*, dealt with the life of the bee. The latter was in many respects an outstanding film. The photography, of a subject which bristles with technical difficulties, was excellent. Close-ups of the bees at work in the interior of the hive, and of the queen (normally very light-shy) laying her eggs, appear on the screen with all the clarity and dramatic effect of a human actor. The film was perhaps a little too long and as a means of teaching the subject was deficient in some respects but, in common with the other two Russian biological films shown earlier by the S.C.R. (*Life in the Karakoum Desert* and *The Force of Life*), it has a rare freshness of approach. Without becoming mystical and unscientific, these films succeed in conveying to the audience the essential romance of nature and of science.

The Special Library

THE well-attended ASLIB (Association of Special Libraries and Information Bureaux) Conference, dealing with the planning and equipment of special libraries and held on April 6 at the Hall of the Royal Institute of British Architects showed that that most essential tool of modern research, the Information Service, is rapidly gaining its proper position in modern society.

Mr. K. Povey, Librarian of Liverpool University Library, stressed the need of the expanding educational programme for university and college libraries, "typifying the place of reading in education by generous seating, lavish display of well-filled shelves and monumental design." He wanted close co-operation between the academic authorities and the librarian and architect with his freshness of mind and the avoidance of undue supervision, petty regulations and 'espionage' in administering the library.

Dr. W. Bonsor, Librarian, Birmingham University Library, discussing the 'Essentials' of the subject, advocated fluorescent lighting, good ventilation, space and comfort for the readers, and quiet, noiseless fittings and floors.

Mr. V. O. Rees, F.R.I.B.A., who has designed many libraries, talked from the architect's side. The architect must know *all* requirements, to create "at the same time interior and exterior effects that blend together in a pleasing whole."

Discussion elaborated the main points, particularly flexibility, adaptability, compactness, the importance of open access, avoidance of 'mortuary' effect and again laid emphasis on the comfort of the staff and the readers before the books.

Mr. B. Fullman, Information Officer of the British Non-Ferrous Metals Research Association discussed the importance of the library in establishments where *laboratory* work is carried on. He wanted these small libraries to be pleasant, with plenty of elbow room, complete access by the workers, free from factory, laboratory and street noises and *not* under a chemical laboratory if flooding is to be avoided. The administration should have an easy formality, allowing smoking and talking.

Mr. E. J. Carter, recently appointed Counsellor for Libraries and Museums in UNESCO, also spoke. He advocated that librarians and architects should get together and do research on library planning and equipment.

The proceedings will be published in full, shortly, by ASLIB.

300 British Council Scholarships

FOR the current academic year over 300 British Council scholarships for study in Britain (normally for one year) have been awarded to students from overseas. A large proportion go this year to students from European countries which were cut off from Britain during the war.

The scholarship-holders have come from 45 different territories in the Empire, Europe, Latin-America, the Near and Far East. Scientific and technical subjects, with the numbers taking each, include: Agriculture 17, Chemistry and Pharmacology 13, Economics 22, Engineering 47, Geology 1, Mathematics 6, Medicine 43, Meteorology 2, Veterinary Science 4.

Places of study include, besides universities, Manchester College of Technology, Battersea Polytechnic, Rothamsted Experimental Station, John Innes Horticultural Institution, Midland Agricultural College (Loughborough), Northampton College of Technology, and the Pharmaceutical Society of Great Britain.

UNESCO Appointments

DR. JOSEPH NEEDHAM has been appointed Science Counsellor of the United Nations Educational, Cultural and Scientific Organisation. Mr. E. J. Carter, secretary of the Royal Institute of British Architects, has been appointed Counsellor for Museums and Libraries.

Institute of Philosophy

THE British Institute of Philosophy came of age last month. Its membership exceeds a thousand, and includes leading representatives of science, politics, industry and commerce as well as of philosophy. A pamphlet about the Institute may be had on application to the Director of Studies, British Institute of Philosophy, University Hall, Gordon Square, London, W.C.1.

T.U.C. Scientific Advisers

THE Trades Union Congress has appointed to its scientific advisory committee Professor P. M. S. Blackett, F.R.S., Professor D. M. Newitt, F.R.S., and also Dr. R. F. S. Schilling (secretary of the Medical Research Council's Industrial Health Research Board) if he is able to serve. All these are members of the Association of Scientific Workers, which is one of the T.U.C.'s affiliated organisations.

History of Medicine

THE first number of the *Journal of the History of Medicine and Allied Sciences* has just reached Britain. The editor is Dr. George Rosen, and there are contributing editors in forty countries, including Professors F. J. Cole and Charles Singer of Britain. The latter has contributed the opening article of the new quarterly, writing on "Some Galenic and Animal Sources of Vesalius".

The Journal is published by Henry Schuman, 20 East 70th Street, New York 21. The subscription rate in the U.S., Canada and Latin America is $7·50, and elsewhere, $8·50.

British Glaciological Society

THE Association for the Study of Snow and Ice has changed its name to "British Glaciological Society". Particulars can be obtained from the Society's Assistant Secretary, c/o Royal Geographical Society Kensington Gore, London, S.W.7.

Index of U.S. Scientific Books

THE U.S. National Research Council has published a comprehensive index of scientific medical and technical books published in the United States from 1930 to 1944. Five thousand copies of the volume are being distributed to United States embassies, legations and libraries throughout the world. All books listed in the volume are in print. The volume contains a selected list of 6,000 titles of technical subjects ranging from astronomy to zoology, with annotations summarising the contents. The volume, which runs to 1114 pages, was edited by Mr. R. R. Hawkins.

Night Sky in June

The Moon.—Full moon occurs on June 14d 18h 42m U.T. and new moon on June 29d 04h 06m. The following conjunctions take place:

June

2d 00h	Venus in conjunction with the moon	Venus	0·2° S.
2d 18h	Saturn ,,	Saturn	3 S.
4d 19h	Mars ,,	Mars	3 S.
9d 03h	Jupiter ,,	Jupiter	4 S.
30d 10h	Saturn ,,	Saturn	3 S.
30d 23h	Mercury ,,	Mercury	3 S.

In addition to these conjunctions with the moon the following conjunctions take place:

June

12d 13h	Venus in conjunction with Saturn	Venus	1·7° N.
18d 05h	Mars in conjunction with Regulus	Mars	0.8 N.
24d 01h	Mercury in conjunction with Saturn	Mercury	1·5 N.

The Planets.—In the early portion of the month Mercury is too close to the sun to be observed but the planet sets at 21h 38m on June 15 and at 21h 44m on June 30, or about 1h 20 after sunset, and can be seen in the western sky. Venus sets at 22h 28m and 22h 17m at the beginning and end of the month respectively and will be conspicuous in the western sky. The portion of the illuminated disk visible on the earth varies between 0·85 and 0·77 between June 1 and 30, and during this period the distance of the planet from the earth varies from 130 to 113 million miles. Mars can be seen for a few hours before midnight, setting at 0h 19m, 23h 39m, and 22h 54m at the beginning, middle and end of the month respectively. From June 1 to 30 the distance of Mars from the earth varies between 159 and 180 million miles, the stellar magnitude changing from 1·5 to 1·7 during this time. Jupiter is visible in the early part of the night, setting at 2h, and 0h 06m at the beginning and end of the month respectively. The planet is stationary on June 15 when it is close to the star θ Virginis. Although the distance of Jupiter from the earth increases from 443 to 481 million miles between June 1 and 31 the stellar magnitude remains the same, that is, +1·8, the alteration of 36 million miles being relatively small. Saturn sets nearly 3 hours after the sun on June 1 and about 2 hours after the sun on June 15 but will then draw too near the sun for favourable observation, and on June 30 sets about an hour after the sun.

There will be a total eclipse of the moon on June 14, partly visible at Greenwich. Totality begins at 14h 17m 53s and ends at 14h 19m 25s.

There will be a partial eclipse of the sun on June 29, invisible at Greenwich. The maximum magnitude of the eclipse will be 0·180, taking the sun's diameter as 1.

Summer Solstice occurs on June 21d 01h when the sun reaches his greatest northern declination. On this day the sun rises at 3h 42m and sets at 20h 21m in the latitude of Greenwich.

Observations of the heavens are more difficult in June, owing to the long days, unless one is prepared to observe fairly late in the night. One constellation is conspicuous at this time and contains several objects of interest—Cygnus the Swan which is nearly overhead at the end of June soon after 1 A.M., but of course can be seen for some hours before this. It is easy identifying this constellation as it resembles a cross and occupies a prominent place in the Galaxy. A small telescope will show that β Cygni is a double and there is a marked contrast in the colours of the two stars—one being a golden yellow and the other a smalt blue. Although 61 Cygni is not a conspicuous star and can just be seen with the naked eye, it is very interesting for two reasons. First of all it was the first star whose distance from the earth was measured. In 1838 Bessell announced that its distance was about 7 light-years and this result has been practically confirmed by more recent determinations, its accepted distance now being a little more than 9 light-years. Then in quite recent times it has been discovered that this star has a planet about 20 times as massive as Jupiter, and it is possible that it has other planets less massive but which cannot be detected at present. For some time it was believed that our solar system was almost unique, planetary systems being very rare, but if this view is correct it seems an extraordinary coincidence that one of the closest stars to us should have a planet. This was discovered after many years of observation only because it was sufficiently near to the earth for its slightly irregular motion due to the revolution of the star and its planet round their common centre of gravity to be detected. We might presume that other stars at greater distances have planets also though it is more difficult to prove it. Another star in the constellation of Ophiuchus is now known to have a planet, and this star is farther away than 61 Cygni. Perhaps many others with planetary systems will be found.

M. DAVIDSON, D.SC., F.R.A.S.

PROGRESS OF SCIENCE—*Continued from p. 135*

In a period of ten years the deposition of worm casts on the surface would be equivalent to a new soil layer an inch or more thick. Darwin adopted a qualitative approach to the fertility of this 'worm manufactured' soil, pointing out that it was nicely granulated mould suitable for plant-growth in general, the germination of seeds in particular. At the Connecticut Experiment Station worm casts have been analysed, and proved to contain nearly five times as much nitrate nitrogen as the ordinary top soil, seven times as much available phosphate, eleven times as much available potassium; the humus content is improved by 55 per cent. The Howard school hold that the gain in fertility due to earthworms is lost when 'artificials' that poison the worms are used. Yet a recent piece of research (undertaken paradoxically, with the purpose of finding out the conditions under which worms are a nuisance—it was carried out for the British Golf Union) shows that it does not matter whether nitrogen is added as sulphate of ammonia, nitro chalk or in humus.

Another attempt to focus attention on Darwin's neglected earthworm studies was made by Sir Arthur Keith in *Nature* (1942, Vol. 149, p. 716). In 1871 Darwin had found that a layer of cinders that he had scattered on the surface a long time before had become buried to a depth of 7 inches. Keith wondered what had happened to those cinders, but found that in the 71 years since Darwin made his observation the cinder level had not deepened at all. Sir Arthur Keith's vivid interpretation of this result is worth repeating: he writes "The main result is to prove that after a time chalk, cinders or other foreign bodies . . . do not continue to be buried deeper and deeper by worm action but reach a stationary level," and proceeds to liken the effect to a stone thrown into a pond—it stops falling when it hits the bottom. He explains it as follows: Worms have a two-fold action. They throw up on the surface a stone-free vegetable mould; they cause flints and all solid objects in the soil to subside very rapidly into a stony stratum, after which these can sink no farther.

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ich cannot be
me time it was
em was almost
eing very rare,
t it seems an
hat one of the
have a planet.
many years of
it was suffici-
or its slightly
revolution of
their common
ted. We might
at greater dis-
ough it is more
her star in the
is now known
star is farther
Perhaps many
stems will be

D.SC., F.R.A.S.

on Darwin's
Sir Arthur
6). In 1871
that he had
had become
red what had
the 71 years
der level had
interpretation
s "The main
nders or other
buried deeper
ary level," and
into a pond—
explains it as
hey throw up
d; they cause
le very rapidly
nk no farther.